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ABSTRACT

The guide for a one-year course in materials processing is part of a series of industrial arts curriculum materials developed by the State of Louisiana. Designed to appeal to both boys and girls regardless of their educational or career goals, the major units in the course are: the productive system, classification of materials, forming materials, separating materials, combining materials, finishing materials, and development of products. The outline format includes performance objectives with suggested activities and resources for the major unit topics and subtopics. Student activities with planning diagrams and illustrated information sheets are appended to each section. Participation in the course is designed to help the student in selection of proper materials for particular products and in selection of appropriate processes for the quantity of production required. (NJ)

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ED120545

CURRICULUM GUIDE FOR INDUSTRIAL ARTS

Grades 9, 10, 11 or 12

MATERALS AND PROCESSES OF INDUSTRY

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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LOUISIANA STATE DEPARTMENT OF EDUCATION

Louis J. Michot, Superintendent
1974

CURRICULUM GUIDE

FOR

INDUSTRIAL ARTS

Grades 9, 10, 11, or 12

MATERIALS AND PROCESSES OF INDUSTRY

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MATERIALS AND PROCESSES OF INDUSTRY

Overview

MATERIALS AND PROCESSES, a study of how man alters materials to increase their value, is a one year course designed for inclusion into the high school industrial arts curriculum. Provision is made within the course for symbolic, vicarious, and direct purposeful learning experiences and the content is formulated to have appeal for girls and boys regardless of their educational and career goals.

Participation in MATERIALS AND PROCESSES will provide the student with a basis for decision-making relative to:

1. The selection of proper materials for particular products: Electrical, chemical, environmental, structural, operational, aesthetical, and thermal.
2. The selection of appropriate processes for the quantity of production required.

Included in the course materials is the overriding issue of both the beneficial and detrimental effects of materials processing, on industrial personnel, the consumer, and the larger society.

The materials, activities and general direction of this publication were adopted from the Kansas State Department of Education Conceptional Base for Industrial Education Project. A special thanks is extended to Lawrence Foth, State Supervisor of Industrial Arts, for aiding Louisiana Industrial Arts teachers in the publication.

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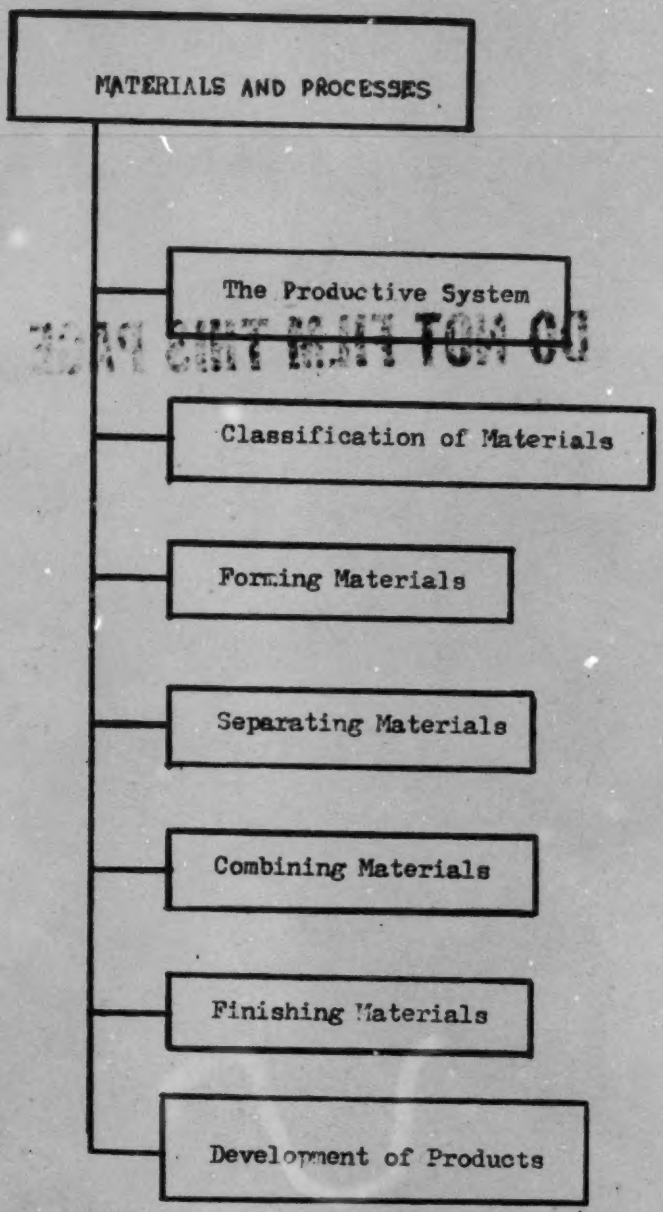


UNIT I - PRODUCTIVE SYSTEM

COURSE: MATERIALS AND PROCESSES

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
Unit I - Productive System	The student will be able to define the productive system as human effort to produce goods and services in hopes of making a profit.	Discussion-demonstration.	
	The student will be able to list and explain the five principal elements of the productive system and clarify the function of each. These being: (1) Research and development (2) Marketing (3) Finance (4) Production (5) Management	Discussion-demonstration. Students will conceptualize a graphic representation of the productive system. If students desire, they may free-hand sketch the product. Students may also use magazines, newspapers, etc. (as outside research) to make an 8" x 11" insert for class notebooks. Students are to list terms, definitions, and find or draw pictures to portray five basic procedures. The student is encouraged to use a variety of colors.	
I. Research and Development	The student will be able to explain the following things about research and development: (1) Its definition (2) Methods of research (3) Process of research (4) Professional persons involved in research and development	Discussion-demonstration.	
	The student will make rough and refine sketches and soft mock-ups of a product.	The students, with the aid of the teacher, will design a product for development. Example: a 3-dimensional tic-tac-toe game that is played with glass marbles. Two sets of four marbles will be required to play the game and the marbles should be stored within the game board body when not in use. The entire product should be small enough to fit inside a lady's purse or man's coat pocket.	See Appendix I-p. 8-9

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
	The student will be able to discuss the division of labor (specialization), its advantages and disadvantages; also, careers related to the manufacturing industry.	Discussion-demonstration.	
	The student will be able to operate machines and tools and produce the product they have designed, using a line production system.	The teacher and students will design and set up a production line system. The students will be assigned a work station and will produce a product in sufficient quantity for each class member to have a take-home product. All activities are to be performed up to, but not including, packaging. See Appendix I for a production line system. Handouts of materials in appendix should be made when needed. Supplies: Set of production tools 2" x 4" fir or spruce 1/16" plastics laminate Ornamental wood screws Sandpaper Screwdrivers Equipment: 2 drill presses Disc sander Radial arm saw Planer 2 routers Table saw Orbital sander Squaring shears	See Appendix I-p. 8-9
II. Marketing	The students will be able to discuss the following things about marketing: (1) Packaging (2) Research	Discussion-demonstration.	

COURSE: MATERIALS AND PROCESSES

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
	(3) Advertising (4) Sales (5) Distribution		
A. Packaging	The students will be able to discuss what items should be included on a package which is to be displayed. These are: (1) Picture or article or display or article contained within (2) Selling price (3) Materials from which article is manufactured (4) The manufacturer's name (5) Source of supply (vendor) (6) Essential selling features (uniqueness and strengths of product) (7) Instructions on how to handle and open package	Discussion-demonstration. With the aid of the instructor the students will do the following: (1) Itemize the content which should be printed on package. (2) Print content on package material. (3) Shear chipboard package material. (4) Fold package into proper shape. (5) Inspect, clean, and package product. Example for a tic-tac-toe package is shown in Appendix I. Supplies: Manufactured tic-tac-toe games Printed packaging stock Steel rule die Marbles, 2 sets of 4 each of 2 colors Cleaning rags Transparent tape Equipment: Press for steel rule die	See Appendix I-p. 9
B. Market Research and Advertising	The student will be able to explain specifically the research and advertising phases for marketing a product. Example: a trivet set. The student will be able to discuss the following about research: (1) Present availability of product (2) Public interest - assessed by researching consumer survey report (a) Customer demand for product	Given a list of guidelines to follow, the student will compose an appropriate advertising media for the sale of a product. With the use of the consumer survey form, the students will conduct a consumer survey involving administrators, teachers, and students of their school, as well as community residents, to determine public receptiveness of the product.	See Appendix I-p. 10-12

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
	(3) Consumer economics The student will be able to discuss the following about advertising: (1) Media (2) Audience, who will use product (3) Principal elements of advertising	Students will use graphic representations, captions, and poster paper to make an advertising brochure for the product. Students will select brochure that will best represent and depict the product. See Appendix I for more information on trivet set, advertising, and consumer survey form. The principles of sales and distribution will be discussed later in this unit.	
III. Production Quality Control	The student will be able to discuss the following concepts of production and apply them to the ensuing production of a product - (trivet set): (1) Production tooling or "tooling up" directed very closely by research and development (2) Production control - planning, routing, scheduling, and dispatching (3) Types of production (4) Quality control - those activities designed to keep defective items from being produced, or, if they are produced, keep them from reaching the market (5) Interchangeability of parts	The student will cut and form metal parts to quality control specifications. Assign students to various work stations and give specific instructions on quantity of metal components to be produced. Cutting and forming operations are to be completed on all metal parts. Production of metal components used in the trivet set will be performed with line production techniques.	

COURSE: MATERIALS AND PROCESSES

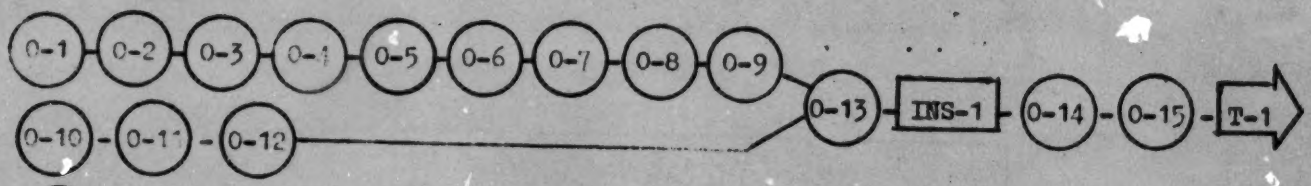
TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
IV. Production Control	The student will be able to discuss the concept of production control as applied to the finishing system for the trivet set. The student will be able to explain the reasons for applying finishes and discuss the types of finishing materials.	Discussion-demonstration. The students will clean the handle and base of the trivet set. They will dry them and apply the primer by following the production controls given to them. See Appendix I for critical path for priming sequence.	See Appendix I-p. 9
V. Management	The student will be able to explain the importance of managing all aspects of the productive system, such as: planning, organizing, and controlling of persons, ideas, and things, as these concepts are in evidence in the various production of products. Example: tic-tac-toe game and trivet set. The student will be able to discuss the following: (1) Types of company organization (2) Top management (3) Operational management (4) Management and personnel (5) Qualities of a good manager (a) His span of control (b) Leadership and decision-making ability	Discussion-demonstration. The instructor will demonstrate: (1) locating fixtures, (2) riveting procedure, and (3) installation and grouting of ceramic tile. The students will combine components with rivets and install ceramic tile to trivet set.	
VI. Sales	The student will be able to explain the concept of selling and distribution as applied to how to sell and distribute a product. Example: trivet set. He will be able to explain the following terms about sales:	Discussion-demonstration. Students will role play personal sales and will collect firm purchase orders outside of class time. Production of the trivet set will continue as students clean grouting off ceramic tile and prime rivet heads and assembly scratches.	See Appendix I-p. 15

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
	(1) Demand (2) Competition (3) Product guarantees (4) Impersonal selling (5) Personal sales		
VII. Production Completion	The student will be able to apply the final coat of finish to assembled product, (trivet set). He will be able to discuss the following: (1) Reasons for application of a final coat over the surface of a primer coat (2) Procedure for application of the final coat	Discussion-demonstration. The student will mask off and spray paint the final coat of finish to the trivet set.	
VIII. Distribution	The student will be able to provide cushioning for the trivet set by dipping it into a heated vinyl liquid and prepare the set for distribution. The student will be able to discuss the following things as applied to distribution: (1) Direct or indirect distribution (2) Transportation (3) Receipt of merchandise	Discussion-demonstration. The student will provide cushioning to the trivet feet, prepare the set for distribution, and distribute the merchandise.	

APPENDIX I

PRODUCTIVE SYSTEM

TIC-TAC-TOE MANUFACTURE



O-1 Surface stock to size with a planer

O-2 Cut to length with a radial arm saw

O-3 Cut dados and grooves with table saw

O-4 Drill marble holes with twist drill

O-5 Bore holes for marble storage with spade drill

O-6 Cut groove with router

O-7 Bevel edges of wooden block with disc sander

O-8 Sand wooden block with orbital sander

O-9 Hand sand and apply oil finish to wooden block

O-10 Shear plastics slide to size with squaring shears

O-11 Cut slot in plastics slide with router

O-12 Finish the slide edges with a disc sander

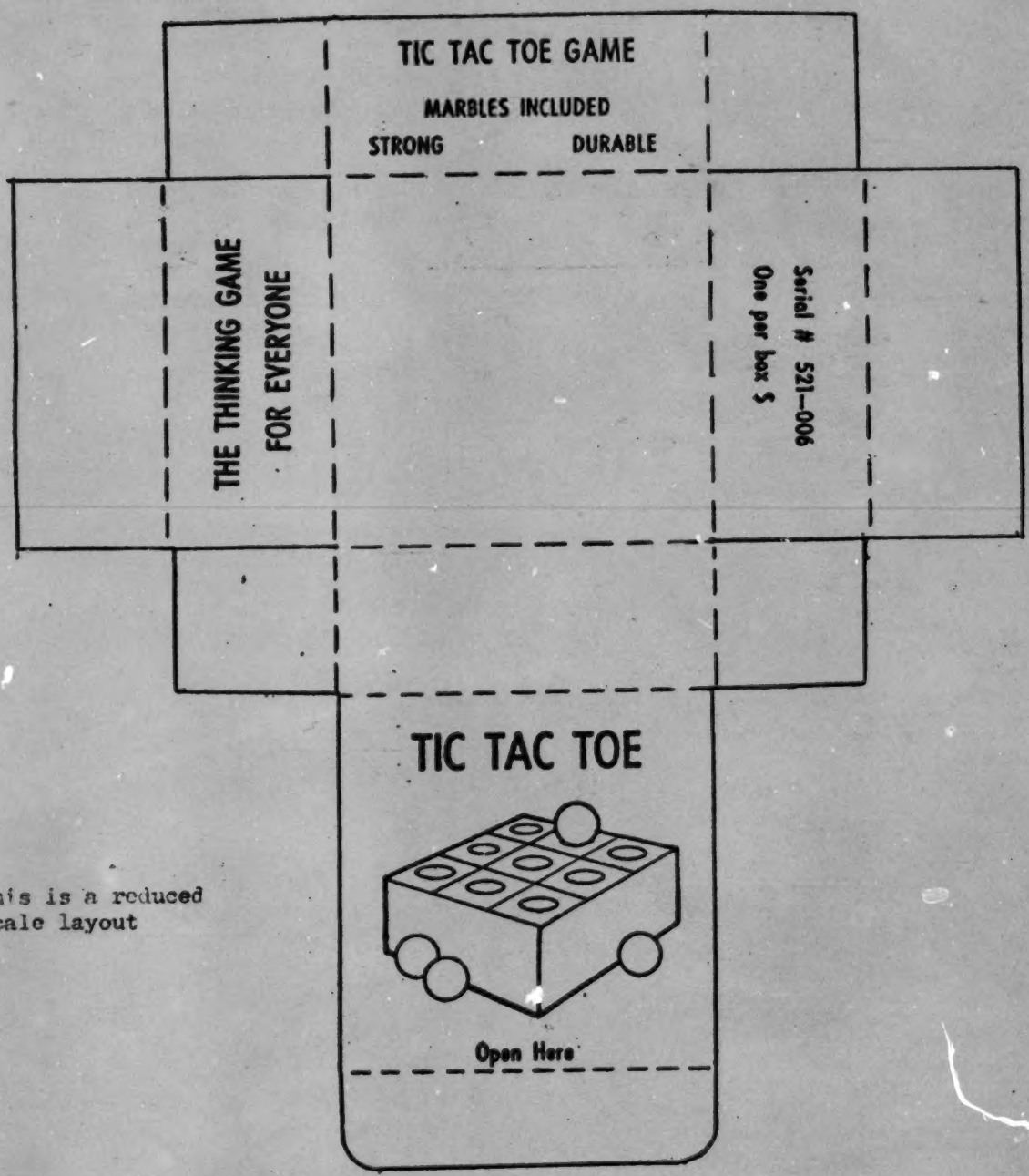
O-13 Assemble slide to wooden block with an ornamental wood screw

INS-1 Inspect manufacturing quality

O-14 Load two sets of marbles, four marbles in each set

O-15 Package Tic-Tac-Toe product

T-1 Distribute the product



This is a reduced scale layout

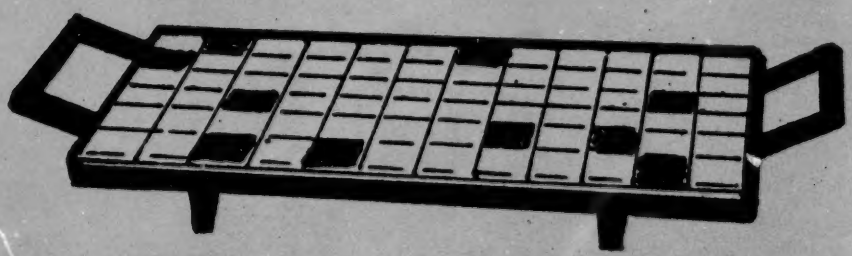
TRIVET SET

SUPPLIES AND EQUIPMENT

Supplies: Captions
Poster paper
Consumer survey form
Glue
Scissors

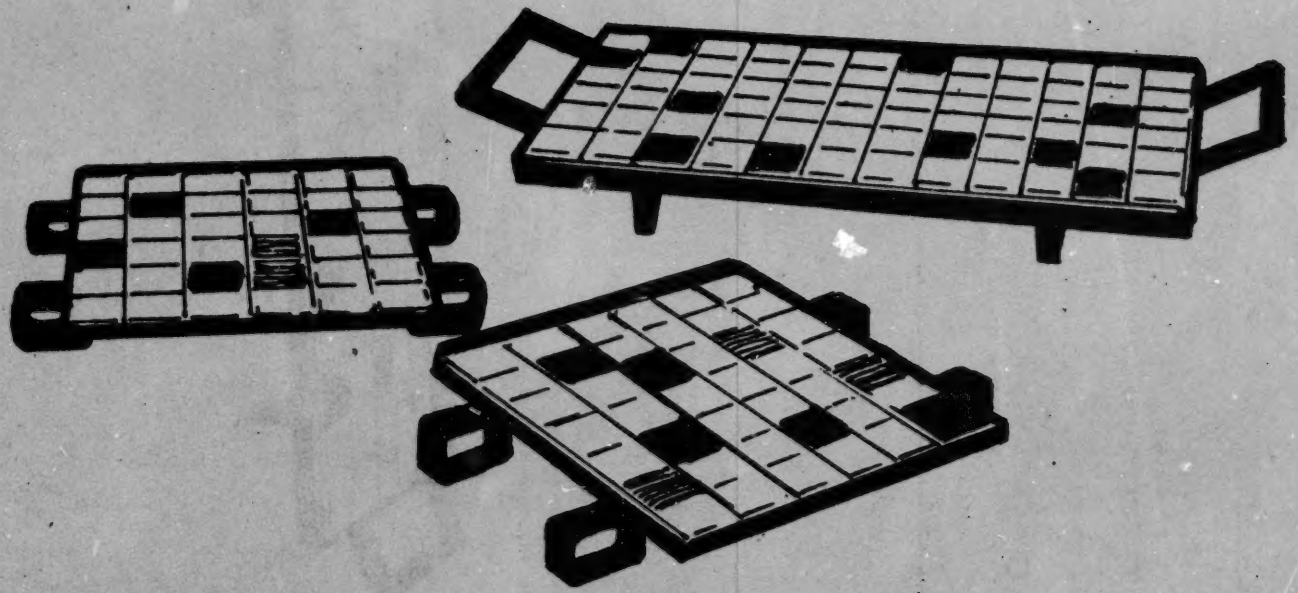
BILL OF MATERIALS FOR CERAMIC - TRIVET SET

Quantity	Name of part	Size	Material
2	Tray	26 ga. x 6 3/8" x 6 3/8"	Mild steel
4	Feet	1/16" x 5/8" x 14"	Mild steel
	Ceramic tile	1" tile - 12" x 12"	Ceramic tile mat
1	Tray	26 ga. x 6 3/8" x 12 3/8"	Mild steel
2	Legs and handle	1/4" x 1/4" x 15½"	Cold rolled steel
	Mastic grout rivets	3/32"	Aluminum



CERAMIC - METAL TRIVET SET

TRIVET SET



ADVERTISING

Instructions: From the captions given below, select those you wish to be included in an advertisement poster. The captions you select are to be cut out with scissors and adhered to the trivet set picture provided for you.

NO MORE WORRIES
OF
BURNT COUNTER
SURFACES

DURABLE

VERY ATTRACTIVE

Nothing is ever too hot.

the trivet set

STRONG

Doesn't Scratch Furniture

IMPRESS

YOUR

FRIENDS

PRICE

LIMITED SUPPLY

FOR THE DANGEROUSLY "HOT" CASSEROLE DISHES

what you always wanted
but was never available
until now

comes in two attractive STYLES

For the LADY of the HOUSE

DECORATIVE YET FUNCTIONAL

MANUFACTURED BY
PRODUCTIVE SYSTEMS
FOR EDUCATIONAL
NEEDS

BUY NOW

PERFECT GIFT FOR MOM

buy the set
or
just one trivet
tray

CONSUMER SURVEY FORM

Product_____ _____

Name of researcher

1. Do you think the overall appearance is attractive?

_____Yes

_____No

2. What would you suggest to improve this product?

3. Do you presently own an item similar to this product?

_____Yes

_____No

4. Would you buy this product if it were now available?

_____Yes

_____No

5. Would you recommend it to others?

_____Yes

_____No

6. What price would you expect the retail store to charge for the trivet tray set?

Name of consumer_____

Address _____

Phone Number _____

CRITICAL PATH FOR PRIMING SEQUENCE

1. Solvent bath - allow the parts to soak in the solution for three (3) minutes (two (2) parts of hydrochloric acid to ten (10) parts of water)

2. Warm water rinse - remove parts from solvent bath and rinse in clear water; for best results, water should be running

3. Dry parts - remove the parts from the rinse and hang them in front of an air source; or all parts can be placed in an oven at low temperature

4. Applying primer - once the parts are inspected, apply the primer as the instructor demonstrated

5. Dry - after the parts are primed, they should be placed in an oven at low temperature or under a fan where a light volume of warm air will pass over them

6. Inspect and store - when the parts are dry they should be inspected for flaws and stored

SUPPLIES AND EQUIPMENT

Supplies: Two large containers to hold five handles and five feet for the trivets plus five small and large trivet bases
Two 8 ounce spray cans of primer
Sheet metal parts for trivet sets
One quart of hydrochloric acid
Two gallons of water
One small fan or oven for drying parts

Note: You may choose to spot weld the metal components rather than riveting them together. Should you decide to spot weld, this process must be completed prior to the priming operation.

NAME_____

PURCHASE ORDER

PRODUCTIVE ENTERPRISE FOR EDUCATION NEEDS INCORPORATED

Purchaser_____ Date_____

Address_____ Phone_____
street city state zip code

Part name	Stock no.	Quantity	Price
Trivet set	521-001		
Trivet tray A	521-002		
Trivet tray B	521-003		
Trivet tray C	521-004		
	Total		

Terms: Cash order C.O.D.

Salesman_____

Delivery date_____

_____
Signature of Purchaser

UNIT II - CLASSIFICATION OF MATERIALS

COURSE: MATERIALS AND PROCESSES

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
Unit II - Classification of Materials	The student will be able to explain a materials classification system and its purpose. The student will be able to define the following generic materials titles: (1) Metals (Ferrous and Non-ferrous) (2) Non-metals (Organics and Inorganics)	Discussion-demonstration. From a list of material captions and definitions the student will make a display chart depicting the system of materials classification. The display chart will be of heavy colored paper and will be placed in the student notebook. See Appendix II for list of material captions and a classification system for metals. Handouts should be made with materials in appendix whenever needed.	See Appendix II-p. 30-31
I. Metals	The student will be able to do the following: (1) Discuss extraction and refining practices (2) Differentiate ferrous and non-ferrous (3) Differentiate elements and alloys (4) Describe distinguishing parameters of metals (5) Discuss metal identification procedure	Discussion-demonstration. The student will correctly label six metal coupons by subjecting them to visual, weight, magnetic, bend, and spark tests. See Appendix II for a classification chart and a reading on identification of metals.	See Appendix II-p. 32-33 (3) p. 18-24
II. Physical Properties of Metal	The student will be able to discuss the physical properties of metal as to its thermal conductivity, magnetism, thermal expansion, and cold working.	Discussion-demonstration. When given the required materials, tools, and equipment, the student will successfully complete four experiments: (1) thermal conductivity, (2) magnetic properties, (3) thermal expansion, and (4) cold working and annealing. In Appendix II there is a reading on the properties of metal, a list of supplies and equipment needed for the experiment, and a written form of the experiments.	See Appendix II-p. 34-42 (3) p. 18-24

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
III. Aluminum	The student will be able to explain how aluminum is produced, its alloys and outstanding qualities	Discussion-demonstration. Teacher may have students write a short paper on aluminum. See Appendix II for a reading on aluminum.	See Appendix II-p. 43 (3) p. 20
IV. Iron and Steel	The student will be able to do the following: (1) Discuss the production and working qualities of iron, steel, and steel alloyw (2) Explain the four or five digit coding system of SAE and ALSI (3) Discuss effect of alloying elements in alloy steels (4) Discuss heat treatment of steel	Discussion-demonstration. See Appendix II for reading entitled "SAE and ALSI System of Steel Classification".	See Appendix II-p. 44 (16) (3) p. 18-24
V. Lumber Technology	The student will be able to discuss the following things about lumber technology: (1) Characteristics of woods compared to other common materials such as metals, concrete, and plastics. (2) Forest conservation and significance of trees (3) Logging (4) Lumber manufacture (5) Manufacture of sheet products (6) Purchasing lumber	Discussion-demonstration. The students will do the following: (1) Compute area and board feet for dimension lumber and sheet material. (2) Construct a sample of plywood. (3) Press out hardboard and particle board samples. (4) Mount samples on display plaque, label, and place into notebook. See Appendix II for reading on "Lumber Technology". Supplies: Sawdust Wood chips Thermosetting adhesive (urea or resorcinol) Wood veneer Display plaque format of	See Appendix II-p. 45-47 (10) p. 78-188 (11) p. 1-79

COURSE: MATERIALS AND PROCESSES

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
		heavy paper Felt tip pens White polyvinyl glue Equipment: Laminating press	
VI. Identification of Woods and Trees	The student will be able to explain the following things about identification of woods and trees: (1) Two main types of woods (2) Characteristics of trees and leaves which aid identification purposes (3) Specific identifying characteristics of (a) Hardwoods (open or close grain, color of heartwood and sap wood, design of grain pattern, density and hardness) (b) Softwoods	Discussion-demonstration. The student is to prepare, mount, and label four hardwoods and four softwoods on two heavy paper display plaques. These plaques will be placed in the student notebook. See Appendix II for reading on "Identification of Woods".	See Appendix II-p. 48-50 (10) p. 77-88 (11) p. 1-79
VII. Paper	The student will be able to discuss the following things about paper: (1) Its definition (2) Types of paper (3) How paper is made (a) Materials used (b) Processes of making paper (4) Conservation of paper (5) The process of making paper by hand	Discussion-demonstration. The students will make a piece of fine paper by hand. See Appendix II for more information on paper making.	See Appendix II-p. 51-53 (18) (4) Ch. 13
VIII. Industrial Paper	The student will be able to discuss the following things about industrial paper: (1) Its identification (2) Kinds (3) Examples of	Discussion-demonstration. The students will construct a 8" x 12" piece of paperboard by glueing together of liners and a corrugated center. It is to be used in the following lesson.	See Appendix II-p. 54-56

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
	(4) The assembly of corrugated board	Supplies: Examples of industrial paper products Paper liner and corrugated paper White polyvinyl glue	See Appendix II-p. 57
IX. Industrial Paper Packaging	The student will be able to list the following steps for building a package from paperboard: (1) layout, (2) printing, (3) cutting, (4) scoring, (5) coating, and (6) folding.	Discussion-demonstration. Given the necessary tools, specifications, and a product to be packaged, the student will layout and cut out a box that fits the packaged article within 1/8 inch on all sides. Supplies: Tic-tac-toe package Paperboard Layout tools Razor blades Scissors Narrow roller (for scoring) Felt tip pens Coating system (pressurized can of clear acrylic finish) See Appendix II for student activity on construction of a package.	
X. Package Testing and Cost	The student will be able to explain the testing of a package and calculating its cost	Discussion-demonstration. The student will perform burst strength tests on paper and calculate the cost of the box constructed earlier. Supplies: Items to be tested Price lists for building Equipment: Pneumatic burst tester	See Appendix II-p. 57

COURSE: MATERIALS AND PROCESSES

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
XI. Plastics	The students will be able to discuss the following things about plastics: (1) Plastics defined - a group of synthetic materials, composed of hydrocarbons having a high molecular weight, which flow at some stage in their development into products (2) Historical development of thermoplastics and thermosets (a) Thermoplastics (b) Thermosets (3) World War II developments (4) Present status (5) Unique characteristics of plastics as compared to non-plastics materials such as: wood, metals, stone, and ceramics (6) Unique characteristics of thermosets as compared to thermoplastics (7) Unique characteristics of thermoplastics as compared to thermosets (8) The working properties of thermoplastics and thermosets	Discussion-demonstration. The student will observe a teacher demonstration on the characteristics of thermoplastics (the polyvinyl worm) and thermosetting plastics (the polyurethane foam). If class time allows, the students will make a few worms and foam a small polyurethane sample. Supplies: Polyvinyl worm kit Disposable cups Tongue depressors for stirring Polyurethane foam, Components "A" and "B" Solvents, lacquer thinner, and cychlohexanone Equipment: Hot plate Soldering gun	(20) p. 9-32 (17) Ch. 1, 2, 3 (7) Ch. 1-5
XII. Composition of Plastics	The student will be able to explain the definition and historical aspects of plastics; also, the raw materials used in making plastics and the chemical composition essential to all plastics material manufacture.	Discussion-demonstration. The students will do the following: (1) Indicate orally the four elements which make up the definition of plastics materials. (2) Describe the thermoplastic characteristics. (3) Describe thermosetting plastics characteristics. (4) Describe orally the significance of the historical dates of 1868 and 1909.	(20) p. 9-32 (17) Ch. 1, 2, 3 (7) Ch. 1-5

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
		(5) Given a list of ten materials, some organic and some inorganic, they will select four which are used as raw materials in the making of plastics materials. (6) Given a list of ten elements, they will identify four elements which are found in many plastics materials. (7) Draw a diagram of the elemental structure of a simple polymer.	
XIII. Identification of Plastics	The student will be able to do the following: (1) Explain the specific gravity test by submerging samples in water (2) Explain the series of solvents used by going through the series with several plastics samples (3) Demonstrate the heat test on thermoplastics and thermosets with a soldering gun (4) Show the burning characteristics of several plastics (5) Manipulate several plastics samples to show their brittleness, toughness, etc. (6) Explain the charting procedure (7) Explain the dangers of working with solvents and open flame (8) Demonstrate the entire identification procedure with an "unknown" sample, such as polystyrent and polyethylene (9) Check out plastics samples to the students	Discussion-demonstration. The student will observe the reaction of eight plastics samples as they are subjected to the specific gravity, solvent, heat, burn, and physical properties tests. They will also chart the results on a form provided to them. Supplies: Baby food jars for containing solvents Solvents - water, toluene, butyl acetate, acetone, and cyclohexanone Tweezers - fabricated from sheetmetal strips Plastics samples - styrene, ABS, acrylic, nylon, polyethylene, polyvinyl chloride, urethane foam, phenolic, and butyrate Equipment: Alcohol burners Electric soldering gun See Appendix II for (1) identification chart, (2) reading on identification procedure.	See Appendix II-p. 58-60 (20) p. 9-32 (17) Ch. 1, 2, 3 (7) Ch. 1-5

COURSE: MATERIALS AND PROCESSES

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
XIV. Textiles and Fabric Construction	The student will be able to define the meaning of the following textile terms: (1) filaments, (2) monofilament, (3) multifilament, (4) staple fibers, (5)filament tow, (6) denier, (7) crimp, (8) weave, (9) knit, (10) yarn, (11) sizing, and (12) finish. The student will be able to describe the characteristics of and uses for textiles.	Discussion-demonstration. Students will cut cloth samples, mount them on a display plaque and label their characteristics. Supplies: Fabric remnants - felt; polyester double knit; muslin; crepe fiber glass; single, double, and woven roving weaves; burlap; and ticking Textile and fabric construction display plaque A variety of textile products Two inch square metal templates Scissors Steel rule die (optional) Equipment: Press for steel rule die See Appendix II for student activity on "Textiles and Fabric Construction" and a textile chart.	See Appendix II-p. 61-63 (9)
XV. Rubber	The student will be able to discuss the following things about rubber: (1) Definition of rubber - an organic material characterized by its high coefficient of friction, flexibility, elastomeric and dielectric qualities (2) Unique properties of rubber as compared to other materials, such as wood, metals, ceramics, and plastics (3) The development of rubber as an industrial material (a) Discovery of natural rubber	Discussion-demonstration. The student will take samples of different types of rubber, mount them on a display plaque, and label their characteristics. Supplies: Heavy poster board display plaque format Rubber cement Rubber samples with an area of $1\frac{1}{2}$" x $1\frac{1}{2}$" 1. Neoprene - open cell 2. Neoprene - close cell 3. Natural gum	(6)

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
	(b) Development of synthetic rubbers	4. Silicone 5. Cold recap tread 6. Adhesive for cold recap 7. Hot recap rubber	
XVI. Rubber Tires	The student will be able to explain the prominence of rubber in transportation tires and the system of tire manufacture.	Discussion-demonstration. Student activity as follows: (1) The student will rough cut material, 1" x 4" and 2" x 4", for wood base of shoe. (2) The student will then laminate the two pieces together. (3) The student will rough cut rubber sole material to shape on bandsaw. (4) The student will cut vinyl upper material to rough shape with scissors using a metal template as a guide. Supplies: Two 1" x 4" x 12" and two 2" x 4" x 12" fir or spruce Wood clamps Glue Scissors Metal roughing template for supported vinyl Supported vinyl Equipment: Radial arm saw Band saw See Appendix II for information on the wooden clogs.	See Appendix II-p. 64-65 (21)

COURSE: MATERIALS AND PROCESSES

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
XVII. Materials with Rubberlike Characteristics	The student will be able to discuss the elastomeric qualities of leather and supported vinyl	Discussion-demonstration. The student will hand sand the wooden clog body to a smooth surface, apply a finish, and tailor the supported vinyl upper of the clog. Supplies: Abrasive papers Finish (fash drying, hand applied, i.e. Deft) Brush Supported vinyl Metal templates Scissors	(6)
XVIII. Recapping Tires	The student will be able to explain the procedure of recapping. (1) Processes (a) Hot recapping (b) Cold recapping	Discussion-demonstration. The students will recite the names and description of the two recapping processes and they will continue working on clogs. The wooden body will be sculptured and the rubber tread will be adhered. Supplies: Wood laminations Contact cement Brush Recap tread, 10/32" (See Appendix B, Lesson 33 for vendor) Equipment: Band Saw Disc sander Drum sander or drill press	(6)
XIX. Vulcanizing Rubber	The student will be able to do the following: (1) Define vulcanization (2) Discuss the need for sulfur (3) Describe the process of vulcanization	Discussion-demonstration. The student will observe a demonstration of rubber vulcanization and will assemble the supported vinyl upper to the clog base.	(6)

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
	(a) Load raw rubber into a metal mold (b) Apply pressure and heat for a specified amount of time (c) Cool mold and remove vulcanized part	Supplies: Tacks Hot recap rubber (See Appendix B, Lesson 34 for vendor) Supported vinyl (tailored) Metal mold for rubber vulcanization Equipment: Laminating press with heated platens	
XX. Rock and Stone	The student will be able to define the following: (1) Rock - a concretion of earthy or mineral matter of inorganic composition (2) Stone - small weathered rock fragments or those portions of rocks which are shaped for buildings The student will be able to identify the stones: granite, sandstone, limestone, shale, slate, and marble. He will also be able to discuss their properties.	Discussion-demonstration. The student will produce a stone identification plaque which includes six stones and a listing of their characteristics. The stones will be packaged in place with a clear acetate blister. Supplies: One stone of each kind: Sandstone Slate Granite Marble Limestone Shale Clear acetate for the blister package Heavy paper plaque format Equipment: Chipping hammers Tumbler Sandblaster See Appendix II for example of "Rock Identification Plaque" and a reading on "Rock and Stone".	See Appendix II-p. 66-69
XXI. Ceramics	The student will be able to discuss the following: (1) Definition of clay (2) Unique properties of ceramics	Discussion-demonstration. Student activities are as follows: (1) The student will differentiate the terms "clay" and "ceramic".	(5)

COURSE: MATERIALS AND PROCESSES

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
	(3) Industrial uses of ceramics (4) Types of clay (5) Firing	(2) The student will identify in writing the names of at least six ceramic products. (3) The student will describe the unique properties of ceramic materials as compared to other materials such as metals, plastics, woods, and rubbers. (4) The student will match the names of at least three types of clays with a description of their common uses.	
XXII. Glass	The student will be able to discuss the following things about glass: (1) Definition of glass (2) Materials used to make glass (3) Properties of various types of glasses such as: quartz, soda-lime glass, and borosilicate glass (4) Glass processing methods (5) Procedure of cutting glass	Discussion-demonstration. Student activities are as follows: (1) The student will identify at least six of the ten chemicals used in glass. (2) The student will choose the correct definition of glass from a list of four alternatives. (3) The student will match the descriptions of glasses with their corresponding names for the following three types: (a) quartz, (b) soda-lime glass, and (c) borosilicate glass. (4) Given only two attempts, the student will cut a piece of glass by using a glass cutter and steel rod. (5) The student will recall orally the sequential steps required to form glass. Supplies: 3/32" lime glass Glass cutter Abrasive paper Variety of glass products See Appendix II for a reading on glass.	See Appendix II-p. 70-71

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
XXIII. Cement and Concrete	The student will be able to define Portland cement and discuss the following things about it: (1) Properties (2) How Portland cement is made (3) Types of Portland cement The student will be able to define concrete and discuss the following things about it: (1) How concrete becomes "cured" (2) How to determine the strength of concrete	Discussion-demonstration. Students are to separate mixed aggregate by using 1/4", 1/2" and 3/4" riddles into fine and coarse aggregate. Supplies: Mixed aggregate 1/4" riddle 1/2" riddle 3/4" riddle Canvas tarpaulin (optional) 5 gallon buckets for aggregate storage Pictures of concrete products (optional)	(8) p. 25-79
XXIV. Mixing and Testing Concrete	The student will be able to discuss the following things about processing concrete: (1) Designing the concrete mix (2) Testing the concrete mix (3) Forming concrete into test specimens (4) Curing concrete (5) Testing cured concrete	Discussion-demonstration. Students will mix concrete and slump test the mix. Also, they will cast four test beams with various reinforcement and two test cylinders from concrete used in the slump test. Supplies: Water Sand Aggregate Cement Slump test form 4 test beam molds 2 test cylinder molds 3/8" reinforcement steel bar Equipment: Concrete mixing equipment	(8) p. 25-79
XXV. Concrete Reinforcement	The student will be able to identify the following types of reinforcements: (1) Bars (2) Welded wire mesh The student will be able to explain the care and installation of reinforcing materials.	Discussion-demonstration.	(8) p. 25-79

COURSE: MATERIALS AND PROCESSES

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
XXVI. Plasters	The student will be able to discuss the following things about plaster: (1) Definition (2) Properties of cured plaster (3) Mixing procedures (4) Shaping plaster (5) Parting agents required on porous surfaces (6) Major types of plaster (7) Major uses for plaster	Discussion-demonstration. After observing the instructor taking a plaster splash, the student will prepare a small wood and clay pattern. A plaster splash will be taken from the pattern on a later date. See Appendix II for a small wood and clay pattern.	See Appendix II-p. 72 (12)
XXVII. Plaster Pattern Making	The student will be able to explain the following things about plaster pattern making: (1) Parting agent for porous surface (2) Mixing plaster (3) Taking a plaster splash	Discussion-demonstration. Students will complete wood-clay pattern and will take a plaster splash of same. The splash will be used as a foundry pattern in a later lesson. Supplies: Plastic containers White plaster Hydrocal plaster Hemp Shellac Alcohol Lacquer 2" shellac brush Petroleum jelly Masking tape Modeling clay 3/4" x 10" x 10" fir plywood for pattern base Wiping rags Equipment: Water sink with plaster trap Spray booth and spray gun Pneumatic drill motor for stirring plaster	

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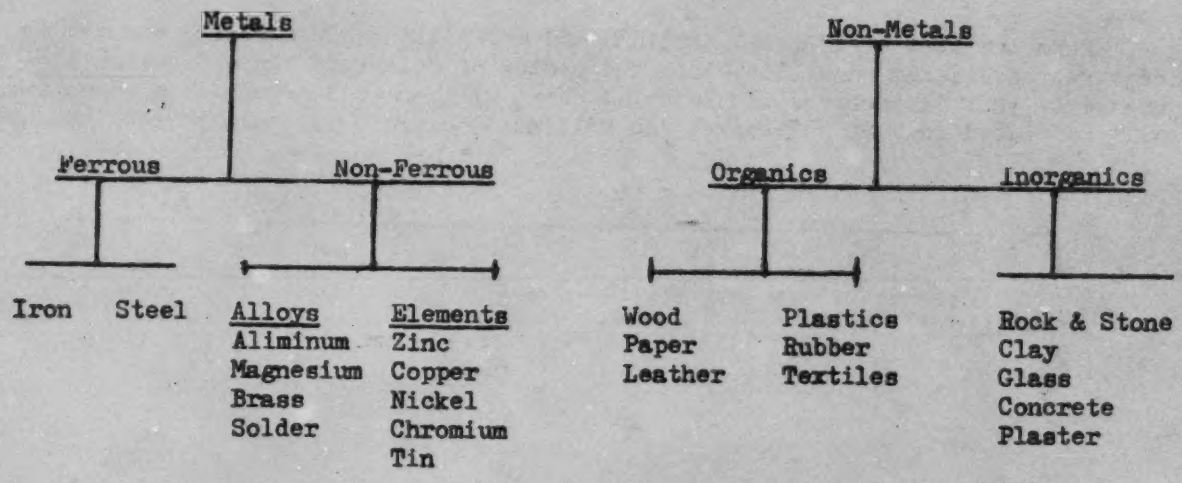
APPENDIX II

CLASSIFICATION OF MATERIALS

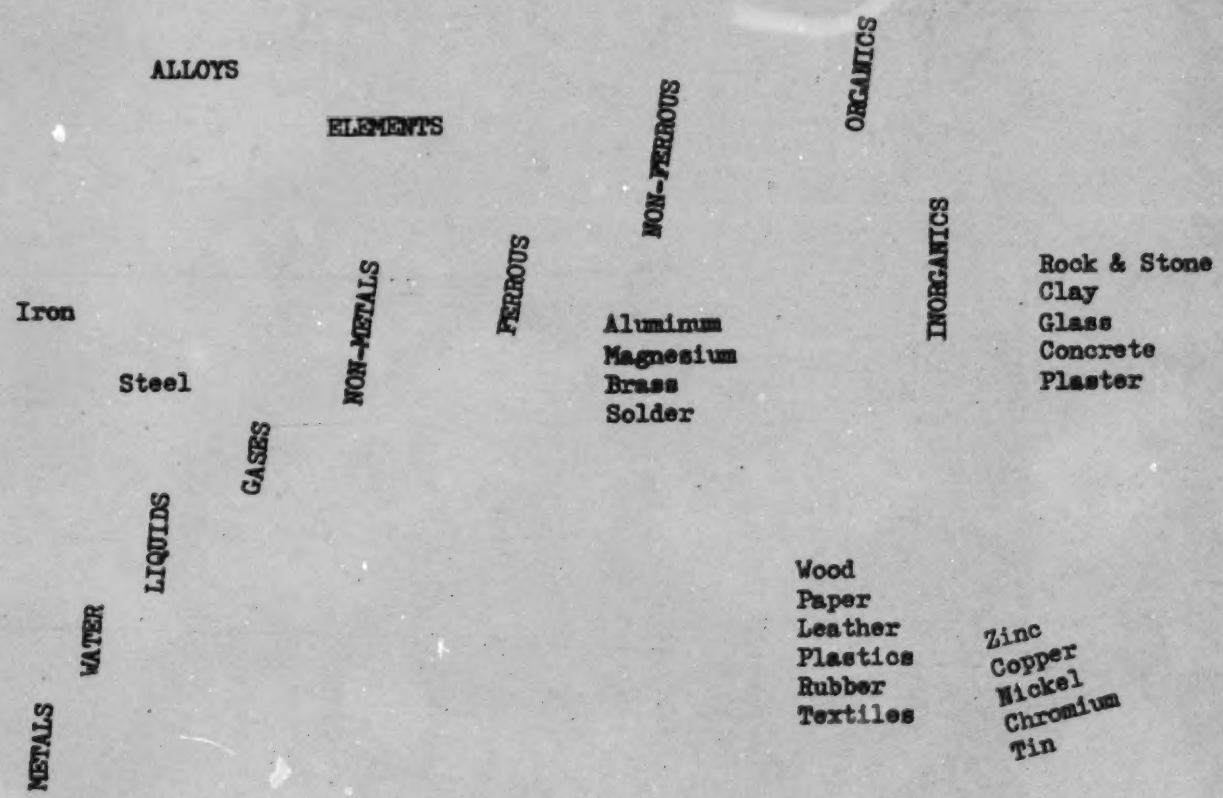
CLASSIFICATION SYSTEM FOR MATERIALS



NAME_____

CLASSIFICATION OF MATERIALS

From the list of material captions and definitions given below, you are to construct a display chart depicting the system of materials classification discussed by your instructor. The display chart will be on heavy colored paper and will be placed in your notebook. You will need scissors and transparent tape.

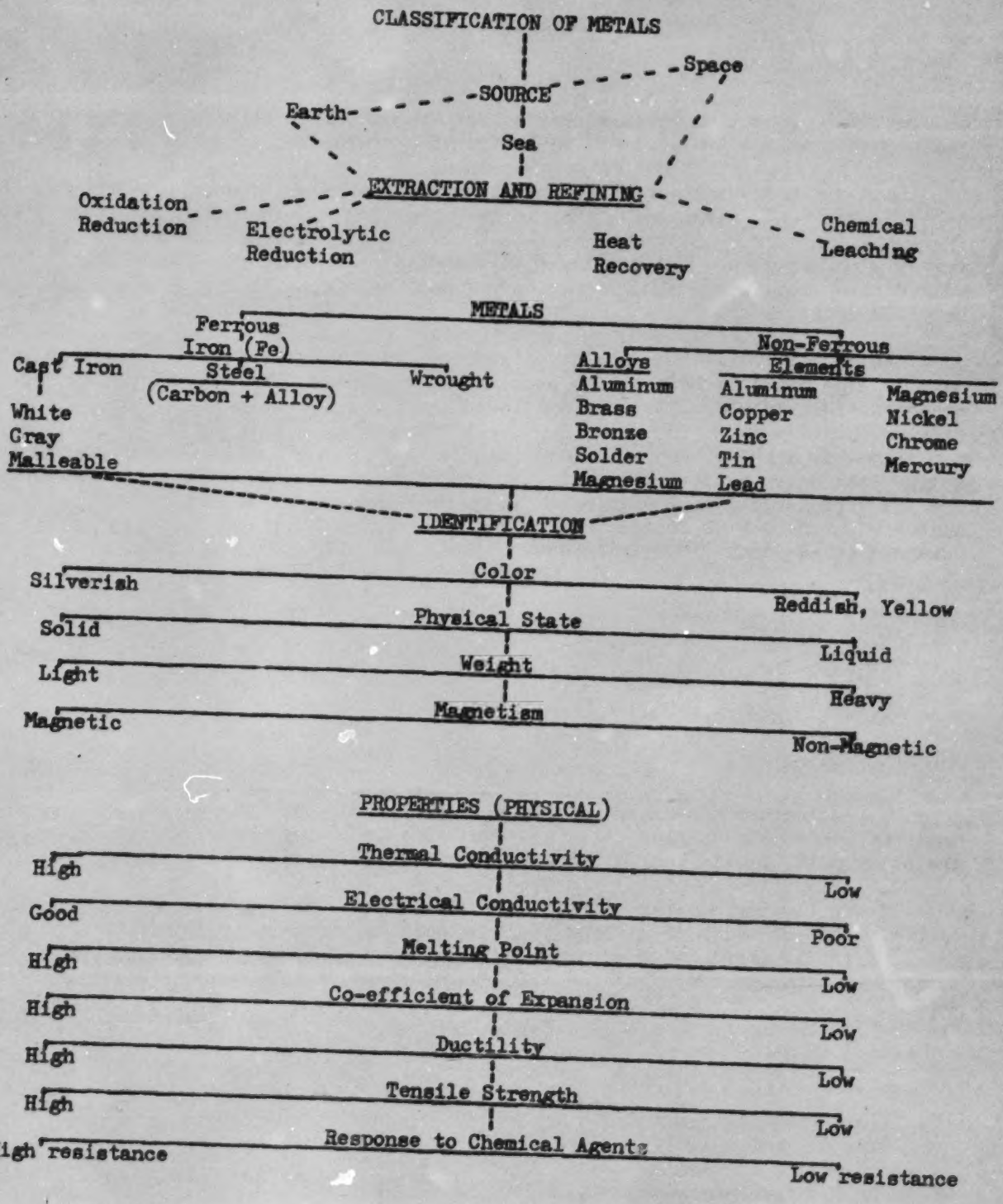


Derived from plant and animal life
(contains large amounts of carbon)

Materials derived from earthy substances characterized by their luster, good electrical and heat conductivity, and heat fusibility.

Composed of matter having no appreciable amounts of carbon; hence, these materials are chemically inert.

NAME _____


CLASSIFICATION OF METALS
SOURCE
Earth
Sea
Space
EXTRACTION AND REFINING
Oxidation Reduction
Electrolytic Reduction
Heat Recovery
Chemical Leaching
METALS
Ferrous
Iron (Fe)
Cast Iron
White
Gray
Malleable
Steel
(Carbon + Alloy)
Wrought
Non-Ferrous
Alloys
Aluminum
Brass
Bronze
Solder
Magnesium
Elements
Aluminum
Copper
Zinc
Tin
Lead
Magnesium
Nickel
Chrome
Mercury
IDENTIFICATION
Color
Silverish
Reddish, Yellow
Physical State
Solid
Liquid
Weight
Light
Heavy
Magnetism
Magnetic
Non-Magnetic
PROPERTIES (PHYSICAL)
Thermal Conductivity
High
Low
Electrical Conductivity
Good
Poor
Melting Point
High
Low
Co-efficient of Expansion
High
Low
Ductility
High
Low
Tensile Strength
High
Low
Response to Chemical Agents
High resistance
Low resistance

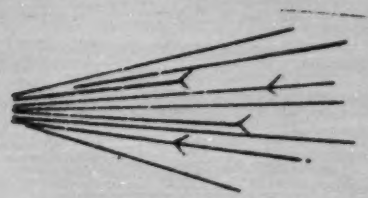
IDENTIFICATION OF METALS

Most metals can be identified in the laboratory by observing their mechanical and physical properties or characteristics: hardness, density, strength, color, and magnetic attraction, as well as by chemical properties.

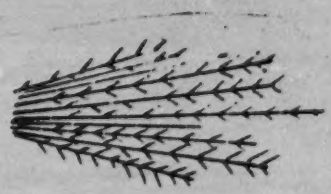
When given the task of differentiating among metal pieces of low carbon steel, high carbon steel, aluminum, brass, copper, beryllium copper, and lead, the following system may be used. First separate them into two groups: (1) silvery and (2) yellowish or reddish. The silvery metals include aluminum, steels and lead. The yellowish or reddish metals include copper and the copper alloys of brass and beryllium copper.

The silvery metals may now be separated into two groups by use of a permanent magnet. The magnetic metals (the ones attracted to the magnet) are steel. The non-magnetic metals are aluminum and lead.

When the steel pieces are placed against a rotating grinding wheel, one at a time, the spark pattern given off will indicate the carbon content of the steels. The low carbon steel will give off a long, dull red spark pattern with a small number of star-like explosions, while the high carbon steel piece will give off numerous bright star-like explosions.



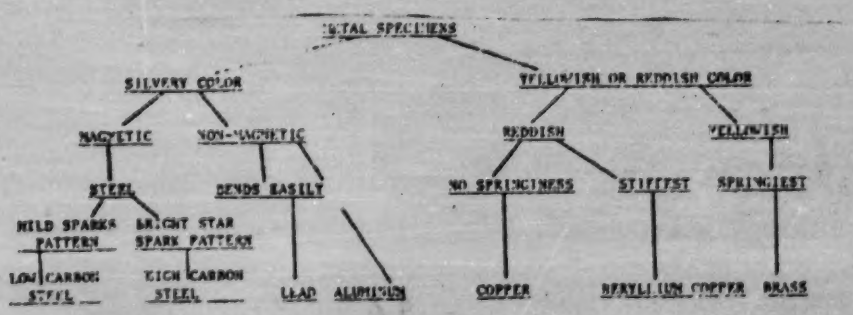
Low Carbon Steel



High Carbon Steel

By bending the non-magnetic silvery metals with your fingers you will notice that one bends more easily than the other. The metal that bends easily is lead; the other metal is aluminum. The lead rod is also heavier than aluminum.

Within the non-silvery metals the reddish metals are copper and beryllium copper. The yellowish metal is brass. By bending the same three non-silvery metals slightly practically no springiness will be observed in copper. The springiest metal is brass and the stiffest of these three metals is beryllium copper.



Thermal conductivity

Heat may be transferred from one region to another by three distinct methods known as convection, radiation, and conduction.

Convection is a process of heating an area by moving a heated material into that area. The heated material gives up its heat and the relatively cool body picks up heat.

Radiation occurs when electromagnetic waves come in contact with material and are partly or completely absorbed and converted into heat.

When heat within a material, such as a rod, flows continuously from the warmer to the colder region, the process is called conduction. The amount of heat transferred per set length of time through a material by this method is called its THERMAL CONDUCTIVITY. The best thermal conductor is metallic silver and the best thermal insulator (poor conductor) is a vacuum.

Thermal conductivity of a material is very important since it tells something of a molecular structure of the material. Metals, for instance, are elements whose atoms contain one or more loosely held electrons; hence, thermal conduction takes place with relative ease.

On the other hand, non-metallic elements, such a phenolic, have atoms in which the electrons are not loosely held. In these elements conduction of heat is not the result of electron movement, but is caused by the jostling of atoms and molecules--a much slower process.

Magnetic properties of metals

The ability of metals or alloys to accept magnetism are listed in one of three categories.

Ferromagnetic (good)	Paramagnetic (fair)	Diamagnetic (poor)
soft iron	aluminum	copper
steel	platinum	zinc
cobalt	chromium	gold

Even though some of these metals have poor magnetic properties, they can be mixed with ferromagnetic metals to give different degrees of strength to the magnet.

To make a permanent magnet the material is subjected to high electrical induction. This process is usually accomplished in the manufacturing process of metals. After this process is completed, the metal will hold its magnetism unless subjected to high heat, physical shock, or a strong demagnetizing field. The temperature at which a magnet loses its magnetism is called the curie temperature.

Thermal expansion of metals

When most materials are heated they increase in size. The increase in size, due to a temperature increase, is called thermal expansion. While an important consideration for many materials, thermal expansion is particularly important as it affects metal objects all around us. Bridges, for example, lengthen in the summer due to the temperature increase. For this reason, they are often set on rollers to allow for the elongation which takes place.

Man has put thermal expansion to use for him in a number of ways. For example, a thermometer uses the metal mercury which is very sensitive to temperature changes. The thermostats, which allow our refrigerators and home heating systems to operate properly, work because of thermal expansion.

When two metals having different rates of expansion are fastened together, they are called a bimetal. When a bimetal is heated, one metal will expand more than the other and the unit will bend, the longer metal being on the outside curve.

The amount of linear expansion of materials is expressed in a number called the coefficient of thermal expansion, which is the fractional increase in length for a temperature rise of one degree. For example, 0.000022 is the coefficient of thermal expansion for aluminum as is shown by the chart below. This means that if a one foot length of aluminum is heated one degree centigrade, it will lengthen by 0.00002 feet. If the temperature goes up two degrees, it will lengthen by twice the amount.

COEFFICIENTS OF THERMAL EXPANSION (linear)

Metal	(in/in/°C)
lead	.000029
solder (50-50)	.000023
aluminum	.000022
brass	.000020
beryllium copper	.000018
copper	.000017
monel	.000014
low carbon steel	.000012
high carbon steel	.000010

* Inches of elongation per inch of length per degree centigrade

The effects of cold working and annealing metals

Cold working is the mechanical deformation of a metal at low temperatures, usually, room temperature. Cold working metal will change the mechanical properties of the metal, usually hardening the metal. The metal can be re-softened by a heat treating process called annealing. Wire drawing is a common cold working operation used in industry. Drawing hardens and stiffens metals. Many times annealing must be used to soften the metal so that the drawing operation can be continued.

Measuring the temperature of metals

Measuring the temperature of metal is an integral part of heat treatment. Two quick and inexpensive methods may be used. The first method, allowing approximate temperatures only, is the color chart, which is used by comparing the color of the heated specimen with the color on the chart.

The second method for measuring temperatures of heated metal is the use of tempil pellets. These pellets are made of a material which melts and causes a smear of hot metal at indicated temperatures. If the pellet does not smear on the specimen, it is known that the temperature is lower than that marked on the pellet package. When the pellet does smear, it is known that the temperature is the same as, or higher than, the temperature marked on the tempil pellet package.

Neither of the above methods is used on a wide scale in industry. Rather, most widely used for temperature measurement are the thermocouple and the optical pyrometer. Six measurement systems are:

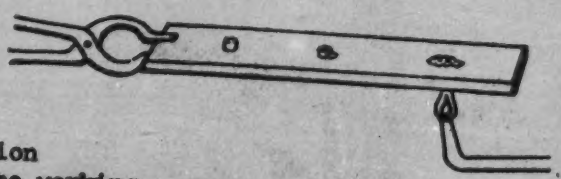
1. Color chart - Visual comparison or matching of color in a heated working steel to a printed color chart of temperatures

Colors for tempering

Fahrenheit	Color	Tool
430	Yellow	Lathe tools
470	Straw	Punch-drills
500	Brown	Axes-wood chisel
540	Purple	Cold chisels
570	Blue	Screw drivers

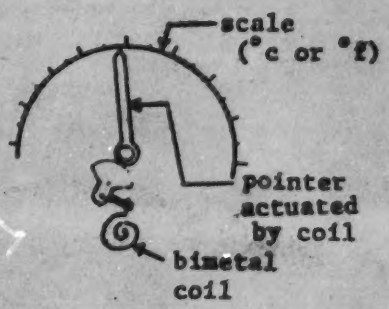
Colors for forging

875	Black red
975	Low red
1450	Cherry red
2000	Lemon yellow
2300	White

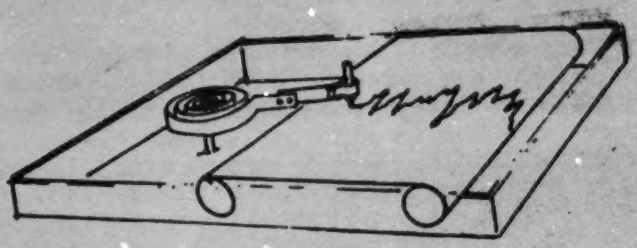


2. Tempil pellets or crayon - Visual inspection reaction of a predetermined melting material reaction as it is applied to the surface of the working metal

3. Metal thermometer - A device that uses the principle of expansion of metals. The reaction of a bimetal coil causes a pointer on a calibrated scale to give a reading of temperature.

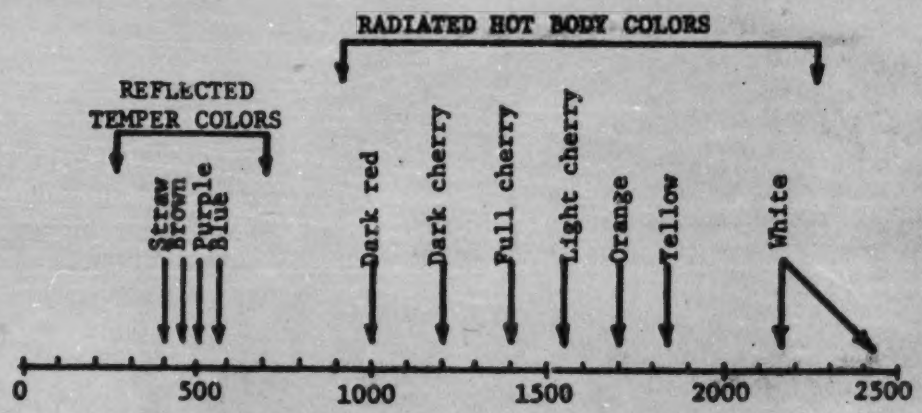


4. Thermograph - This device combines the metal thermometer and a recording device to give a constant printed readout



5. Pyrometer - A pyrometer is a device using the principle that an electric current is generated in a thermocouple (two dissimilar metals welded together) as it increases temperature and thus, gives a readout on a millivoltmeter

6. Optical Pyrometer - An optical pyrometer is a sensory device that registers the degree of brightness of the color spectrum in metal as it reacts to heat.



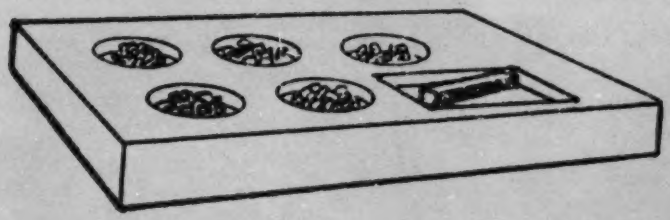
SUPPLIES AND EQUIPMENT

Supplies: 4 inch lengths of 1/8" brass, aluminum, steel, and phenolic rod
Candle or beeswax
Alcohol burner
Magnetizing coil
4 inch "C" clamp
One pound tinners rivets
Thermal conductivity testing structure
Magnetic properties kit
Monel strip
20-28 gauge x ½" x 5" mild steel and brass strips
Hand lever hole punch
Micrometer
.080" - .100" soft copper wire
Wire drawing die
Ball peen hammer
¼" diameter x 2" aluminum and low carbon steel

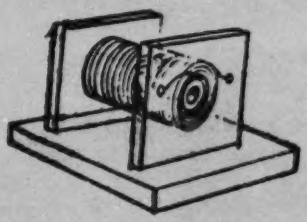
Equipment: Soldering furnace or torch for annealing
Machinist vise

NAME_____

MAGNETIC PROPERTIES OF METALS



Magnetic properties kit



magnetizing coil

Experiment #1

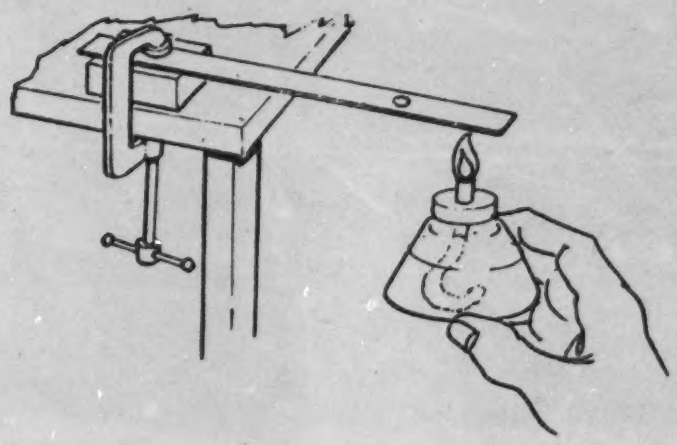
Using samples of different metals provided in the class, take a permanent magnet and see which metals have magnetic properties. List the metals under the three terms used to classify metals as to their ability to be magnetized.

Experiment #2

Using a permanent magnet, pick up as many thumbtacks as the magnet will hold. Remove the thumbtacks and strike the magnet sharply with a hammer. Now try and pick up the same number of thumbtacks. Can they all be picked up? Why? You may remagnetize the bar of steel with an electrical coil and a direct current source.

Experiment #3

Clamp a Monel strip to a table and place a button magnet about an inch from the end. Using an alcohol burner, heat the Monel strip. The button magnet will move away from the heat. This is because the curie temperature is about 150°F and Monel will lose its magnetic properties.



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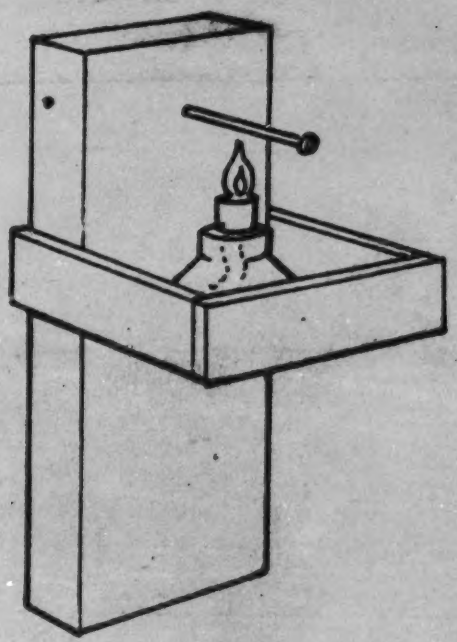
PHYSICAL PROPERTIES OF METALS

THERMAL CONDUCTIVITY

Experiment Instructions

Set up the experiment as indicated below using brass, aluminum, low carbon steel, and phenolic rod. Record and compare your results on each. Check to be sure that the rod lengths and diameters are the same to insure accurate results during the experiment.

Cut all rods to four inch lengths and scrape some candle wax (or suitable substitute) on the end of each rod. Insert the other end of the rod into the wire holder. Start heating the rod and determine the time it takes to melt the wax for each rod. You will need a watch with a sweep second-hand. These times will be used in comparing the thermal conductivity of the different rods. Since wax melts at a specified temperature and since the wax on one rod melts in less time than on another, it can be stated that heat was conducted more rapidly through that rod. Therefore, we can conclude that its thermal conductivity is greater.



NOTE: Record the time required to melt the wax for each of the four rods.

BRASS	ALUMINUM	STEEL	PHENOLIC

NAME_____

THERMAL EXPANSION OF METALS

Experiment #1 - Bimetals

Cut two 20-28 gauge x 1/2" x 5" metal strips--one of steel and the other of brass. Fasten together with four, one pound tinners rivets.

Hold the bimetal with pliers and heat it over the alcohol burner.

In which direction does the strip bend?_____

Which metal expanded the greatest amount?_____

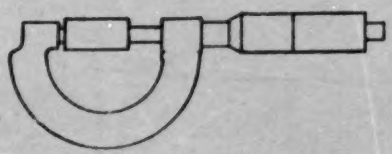
Cool the bimetallic strip in cold water. What is the direction of bending?

_____

What do you thirk would happen if the bimetal was cooled to sub-freezing temperatures?_____

Experiment #2 - Thermal expansion

Cut off a 2 inch section of 1/4" steel rod. Measure the exact length of the rod with a micrometer and record below. Heat the rod along its full length for a few seconds with the alcohol burner. Once again, use the micrometer to measure the length of the rod and record the measurement. From your recordings, notice the differences in measurements.



Some metals lengthen more than others. Repeat the above experiment with a section of aluminum and record the measurements.

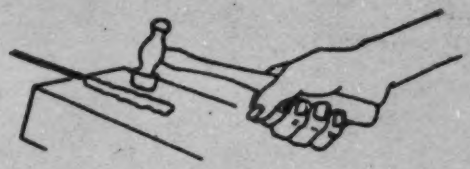
	ALUMINUM	LOW CARBON STEEL
Room temperature		
Heated with alcohol burner		

NAME_____

THE EFFECTS OF COLD WORKING AND ANNEALING

Experiment #1 - Cold working by hammering

Take a copper wire (6" - 8", .080" - .100" diameter) and hammer one end of the rod flat. Check the comparative strength of the hammered end versus the regular end by trying to bend each end of the rod by hand. The hammered end should be more difficult to bend.

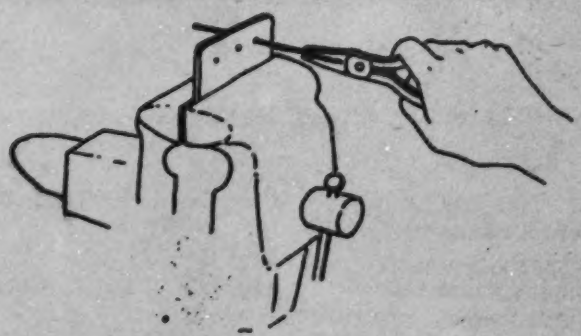


Experiment #2 - Annealing

Use the copper rod prepared in experiment #1. Heat the hammered end of the rod to approximately 600°F. After cooling in water, try the same test used previously. How does the stiffness compare? The annealing process will have softened the rod after the cold working has hardened it.

Experiment #3 - Cold working by drawing wire

Cut off two pieces of .069 copper wire about six inches long. File a taper on one rod so that it goes through the largest hole in the draw plate. Using pliers and oiling the rod before each drawing, pull the rod through the largest hole. By bending, compare the stiffness to the other piece of undrawn copper wire. Anneal (heating to approximately 600°F) the piece of copper wire that had been drawn through the next hole; compare the two wires by bending. Which has more resistance to bending? Why? Oil the same wire and draw it through the next hole. By bending, compare its stiffness to the first copper wire; one might expect the thinner wire to bend more easily. Does it?



ALUMINUM CLASSIFICATION

The aluminum industries have adopted a uniform system to identify the various types of aluminum. This system will be briefly explained below:

. Common aluminum alloys are:

1100	3003
2014	2017
2024	4032
4043	5052
6053	5056
6061	6066
7075	

First digit explanation

1 xxx - Non-alloyed aluminum
2 xxx - Copper base
3 xxx - Manganese base
4 xxx - Silicon base
5 xxx - Magnesium base
6 xxx - Magnesium and silicon base
7 xxx - Zinc base

The second digit of the series simply shows some control or modification that was used in the production of the aluminum. This number is of importance largely to the producer.

The last two digits of Group 1 indicate the degree of aluminum purity which is expressed in hundredths of 1 percent. The last two digits in other groups identify specific alloys in the group.

The hardness of heat-treatable aluminum alloys is shown by the letter "T", which indicates a heat-treatable aluminum, and is followed by a number. The number designates the kind of temper treatment that was used.

Temper designations

O - Annealed or recrystallized. Softest temper or wrought alloy.
F - As fabricated
H - Cold worked
W - The unstable condition following solution heat treatment
T2 - Annealed. Cast products only.
T3 - Solution heat treated, then cold worked.
T4 - Solution heat treated, and naturally aged to a substantially stable condition
T6 - Solution heat treated and artificially aged

SAE and AISI SYSTEMS OF STEEL CLASSIFICATION

The Society of Automotive Engineers (SAE) and the American Iron and Steel Institute (AISI) have developed a classification system for coding steel. A four or five digit number specified the type of steel in the first digit, the percent of alloying element in the second digit, and the amount of carbon in the third, fourth, and fifth digit in cases where high carbon content is present.

3% Nickel

Example: $\frac{2}{\text{Nickel}}$ $\frac{3}{}$ $\frac{50}{.50\% \text{ carbon}}$

Coding System
Types of Steel

(1) Carbon

(2) Nickel

(3) Nickel-chromium

(4) Molybdenum

(5) Chromium

(6) Chrome-vanadium

(7) Tungsten

Common Carbon
Steel Numbers

Mild steel - 1020

Medium carbon - 1045 and 1065

High carbon - 1095

Common Alloy Steel Numbers

Nickel - 2350

Nickel chromium - 3230

Molybdenum - 4130

Chromium - 5150

Chrome-vanadium - 6140

Tungsten - 7260

LUMBER TECHNOLOGY

The lumber industry provides functional and aesthetic materials which our civilization has learned to appreciate. The beauty and serviceability of woods, rarely matched by any other material, place these materials in high esteem all over the world. The workability of woods has made them a prize choice for the craftsman of many ages. In years past, the lumber industry was concerned with removing as much timber as possible without regard to the conservation of wild life, topsoil, or future growth of timber. Today, however, the lumber industry is more aware of the need for controlled harvesting of trees, the protection of wild life, the prevention of forest fires, and conservation of valuable top soil. Tree farming is a systematic method of growing trees for the production of lumber, paper, and other wood products. Some of the larger lumbering and paper making companies own tree farms and manage them so that timber is grown more rapidly than it is being used.

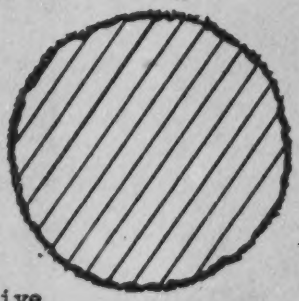
LOGGING OPERATIONS

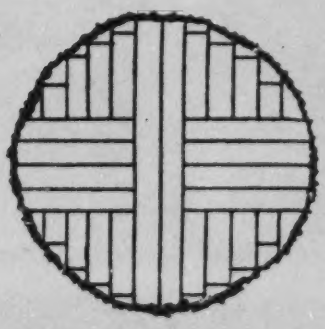
Most logging operations, done by power tools and power machines, saw the trees neatly and quickly and power tractors tow the logs to the nearest clearing where they are loaded on large trucks for transport to saw mill. Before being sawed into lumber, the logs are stored in the mill pond which prevents insect damage, fire, splitting, and makes it easier to sort out and move the logs to the power conveyor that will carry them up to the saws.

MAKING LUMBER FROM LOGS

With huge power saws, which are usually band saws or, in some cases, a high pressure jet of water, the logs are cut into timbers, planks, or boards. Lumber over 4½" thick is "timber"; lumber from 4½" to 1½" is "plank"; while material under 1½" is referred to as "board". Two methods of sawing logs are:

a. Plain sawing - The quickest and least expensive way to cut a log is to pass it back and forth through the saws. Most softwoods are plain sawed.





b. Quarter sawing - For hardwoods, it has been found that the grain pattern is more attractive and the lumber warps less when the log is quarter-sawed. Since there is more waste and it takes longer, quarter-sawed lumber is usually more expensive than plain sawed lumber.

LUMBER SIZES

When a 2 x 4 is sawed from a log it actually measures 2" x 4"; but its surface is still rough from the coarse saws. However, after it has been smoothed on its surfaces and edges, the lumber is smaller than before. Therefore, a purchased 2 x 4 measures about $1\frac{1}{2}$" x $3\frac{1}{2}$". All smoothed lumber purchased in standard sizes is actually a little undersize. A 1 x 8 board; for example, measures about 3/4" x $7\frac{1}{2}$" and a 2 x 10 plank measures about $1\frac{1}{2}$" by $9\frac{1}{2}$".

DRYING LUMBER

Wood is composed of tiny cells and, when the tree is growing, these are filled with moisture and sap. When the tree is cut down and sawed into lumber, this moisture begins to evaporate, permitting the cells to shrink. Unless this evaporation is carefully controlled, the lumber will shrink unevenly causing warping and cracking.

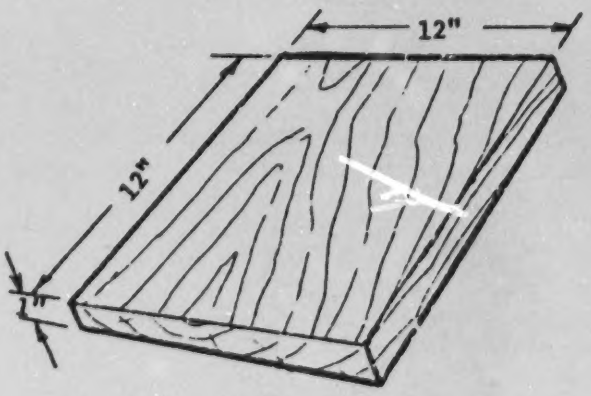
To prevent excessive warping and shrinking, most lumber is dried before being sold to customers. Lumber may be air dried, but the better lumber is kiln dried.

In the process of air drying, lumber is simply stacked in piles with space between the pieces, so that air can circulate around each piece. This takes several months and the drying cannot be carefully controlled. After correct air drying, the wood will have minimum moisture content of fifteen percent.

In the process of kiln drying, the lumber is stacked in piles with spacers between the boards and placed in a kiln or oven in which moisture, air, and temperature are controlled. Properly kiln dried wood will have less than ten percent moisture content.

PURCHASING LUMBER AND WOODEN MATERIALS

Most lumber is sold by the board foot. One board foot is equal to a piece of lumber 1" thick, 12" wide, and 12" long. Lumber less than 1" thick is usually figured as though it were a full inch.



The number of board feet in lumber is figured by multiplying the thickness in inches by the width in inches, times the length in feet, all divided by 12. The formula for figuring board feet is shown below:

$$\frac{t'' \times w'' \times 1'}{12} = \text{board feet}$$

If the length is figured in inches, the following formula should be used:

$$\frac{t'' \times w'' \times 1''}{12 \times 12} = \text{board feet}$$

Plywood, pressed wood, and similar material are sold by the square foot.

USES FOR WOOD

Of the one-half million new houses built in this country each year, many are made almost entirely of wood. Even houses made from other materials use wood for doors, paneling, and trim. Heavy construction work makes use of lumber for cement forms, scaffolding, bridging, and piling. Some of the finest lumber is used by the furniture industry to manufacture millions of dollars worth of furniture each year. Less valuable lumber goes into crating which is used for packaging and shipping.

Besides the millions of collars worth of lumber produced, wood is used to produce plastics and charcoal. Billions of dollars worth of paper is produced each year from wood pulp and wood is used to produce paints, perfumes, explosives, antifreeze, and disinfectants.

HARDBOARD AND PARTICLE BOARD

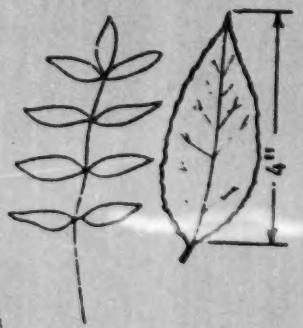
Plywood is made by cross-banding thin plies of wood together. Three or more plies, always in odd numbers of veneer, at right angles to the adjacent ply provide a flat stable material which has strength characteristics far greater than that of solid wood. The majority of veneer used in plywood construction is cut by a rotary process but for fine cabinet plywoods the veneer is plain or quarter sliced.

One of the great advantages of plywood is its availability in large sheet forms. This reduces construction time in flooring and roofing jobs for example.

Hardboard consists of wood fibers and natural wood lignin which have been pressed under extreme pressures. Sawmill residue and low quality logs, formerly waste, are used for making hardboard products.

Like hardboard, particle board is produced from sawmill residue and low quality logs. However, in the case of particle board, the materials are in the form of chips. Adhesives and pressures bond the chips into a rather stable and useful sheet used as a construct underlayment material.

IDENTIFICATION OF WOODS

NAME	SOURCE	PROPERTIES	USES	APPEARANCE
(Hardwood) ASH 	Eastern half of United States except along the Atlantic coastal plain, Gulf coast, and Florida	Heavy, strong, stiff, excellent flexure, and shock resistant, Weight: 42 lbs. per cu. ft.	Tool handles, furniture, sporting equipment and athletic equipment	Large open pores, heartwood brown, sometimes reddish, summer wood has white dots or lines which are pores
CHERRY 	Maine, westward to eastern North Dakota and southward to central Florida and Texas	Moderately heavy and hard, stiff, strong, very stable and high stock resistance Weight: 35 lbs. per cu. ft.	Furniture, backing block for printing industry, patterns and flasks for metal-working industry	Close-grained, heartwood light to dark reddish brown
WALNUT 	Vermont westward to Nebraska, southward to southern Georgia and Texas. Commercial production located in the central part of this range	Heavy, hard, strong, stiff, and good shock resistance Weight: 38 lbs. per cu. ft.	Furniture, gunstocks, radio and television cabinets, veneers	Open-grained, heartwood chocolate brown, sometimes with a purplish cast. Sapwood white

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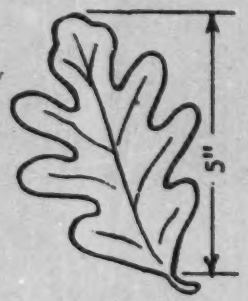
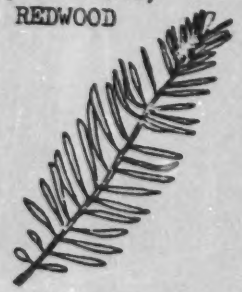
IDENTIFICATION OF WOODS

NAME	SOURCE	PROPERTIES	USES	APPEARANCE
(Hardwood) MAHOGANY (Philippine) 	Philippine Islands	Similar to genuine mahogany, but coarser in texture and appearance. Weight: 37 lbs. per cu. ft.	Lumber and veneer for furniture, built-ins, and paneling	Open-grained, dark red variety varies from pale to dark reddish brown. Light variety ranges from light red to straw. Sapwood is pale grayish or reddish brown.
MAPLE, HARD 	Maine to Minnesota, southward to eastern Texas and northern Mississippi, Alabama, and Georgia. Largest stands in the lake states and northeast.	Heavy, hard strong, stiff, high shock resistance. Excellent endurance quality, no odor or taste. Weight: 44 lbs. per cu. ft.	Furniture, flooring, handles, woodenware, bowling pins, and chopping blocks. Sap used for syrup and sugar	Close-grained, light reddish brown or tan, sapwood is off-white occasional dark mineral streaks
WHITE OAK 	Eastern United States from western Minnesota to western Texas	Heavy, very hard, high in strength properties. Subject to large shrinkage during seasoning. Pores filled with tyloses. Weight: 47 lbs. per cu. ft.	Flooring, furniture, general millwork, boxes, and crates, outstanding for kegs, barrels, and casks	Large pores, heartwood grayish brown, large wood rays ½" to 5" long

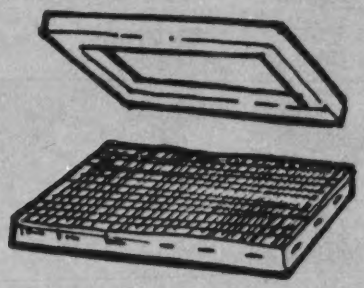
IDENTIFICATION OF WOODS

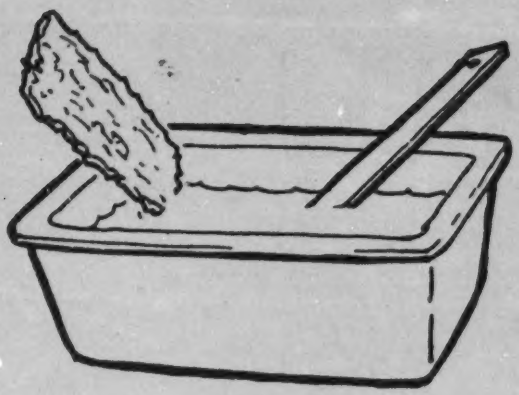
NAME	SOURCE	PROPERTIES	USES	APPEARANCE
(Softwoods) REDWOOD  3/4" needles	Along or near the California coast in narrow, irregular strips	Moderately light, moderately hard, strong, and stiff. Highly decay resistant. Weight: 28 lbs. per cu. ft.	Planks, dimension lumber, joists, planks, posts. House siding, outdoor furniture, and tanks.	Heartwood is a deep reddish brown. Has no distinctive odor, taste, or feel.
DOUGLAS FIR 1/2" needles	Rocky mountains west and from Canada to Mexico. Largest and fastest growth in Oregon and Washington.	Moderately heavy, very stiff, moderately strong, hard, and shock resistant. Readily kiln-dried. Weight: 33 lbs. per cu. ft.	Sash, doors, railroad cars, boxes and crates, timber, piling, and plywood	Heartwood is orange red or sometimes yellowish. Brownish resin streaks in the summerwood. Has a distinctive odor.
WESTERN WHITE PINE 5 needles	Canadian border southward into western Montana and northern Idaho and along the Cascade and Sierra Nevada mountains through Washington, Oregon to Central California. Heaviest in northern Idaho and adjacent parts of Montana and Washington.	Moderately light, soft, weak, and stiff. Is not easily split by nails. Weight: 27 lbs. per cu. ft.	Lumber, construction, boxes, and millwork	Heartwood is cream colored to light brown. Resin canals are abundant.

MAKING FINE PAPER

A piece of hand-crafted paper, approximately 6" x 8", is to be made by the procedure shown below.

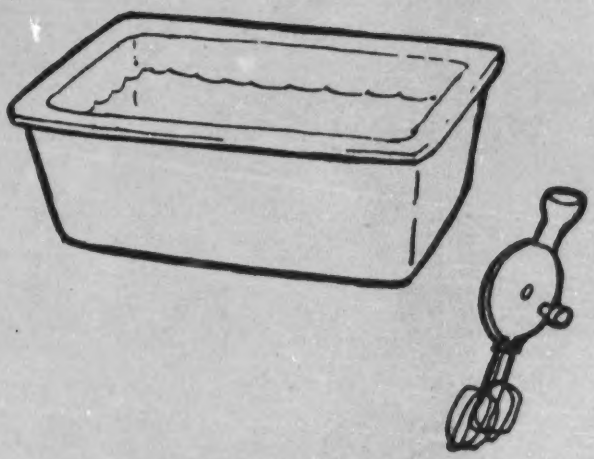
1. Select mold called a "wire".



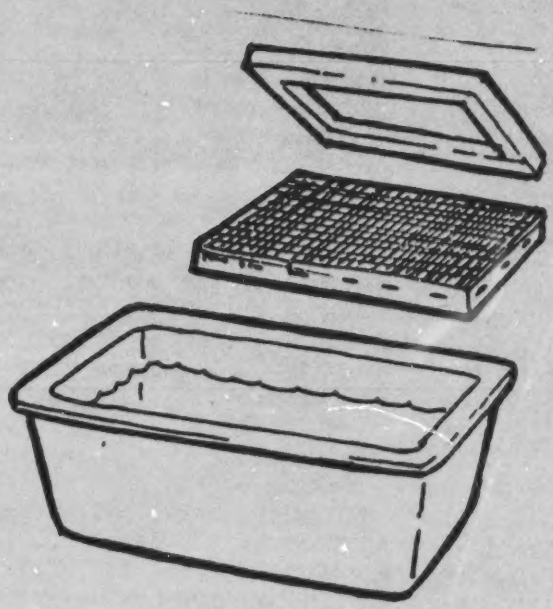


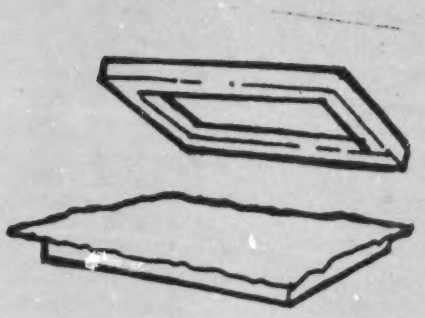
2. Fill tub 3/4 full of warm water and shred pulp into the water while stirring the mixture.

3. Boil two tablespoons of laundry starch in two cups of water. Pour in tub and beat with egg beater.



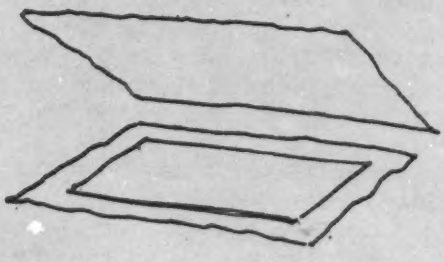
4. Insert "wire" down to the bottom of the tub. Place the wooden frame over the "wire" and pull the "wire" with frame out of the tub while in a horizontal position.



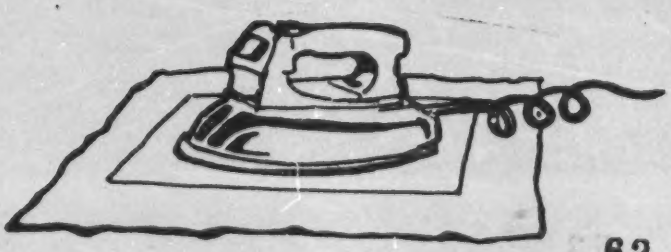


5. Separate the two mold components and place blotter paper over the "wire".

6. Pull blotter off the wire and place a second blotter over the wet paper matting. Press dry. This process may have to be repeated several additional times with additional sheets.



7. Roll out excess moisture from sheet.



8. Iron with a low heat to desired surface gloss.

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INSTRUCTIONS FOR MAKING PAPER

A container, such as a dishpan, approximately 6" deep and wide enough to allow a free movement of the box and screen is necessary. Fill the pan with water and then tear apart or pulverize a small piece of the raw pulp stock which is in the kit. A little bit goes a long way, so it is best to start with a small quantity and keep checking it on the screen until the right amount of pulp is evident.

The pulp must be dissolved thoroughly in the water, and this can be done by vigorously stirring so the pulp is held in suspension in the water. The water will appear dull, dirty, and murky. When the pulp and water have been mixed to the consistency you desire, immerse the box and screen (stir immediately before immersing) into the water and shake from side to side while raising slowly. Shaking the box side to side causes the pulp to intermix (cross grain) to give strength to the sheet and also has a tendency to smooth our the pulp.

Raise the box and screen and let the water drain completely out for just a minute or so, and then separate the wood box and the screen. Be careful not to disturb the pulp which has deposited on the screen. Place the screen with the pulp between the wool pads and press gently so that the wool will absorb some of the water. Then remove the screen from the wool pad and place it between the blotting sheets and apply gently pressure. This will remove some more water from the pulp or the paper sheet. Lay the sandwich on smooth flat surface, remove top blotter and very gently separate the screen from the pulp, leaving the pulp on the bottom blotter.

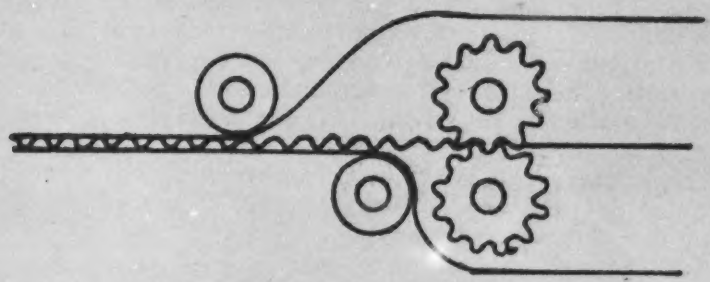
In order to dry this sheet further, put a piece of blotter over the pulp. Use a hand iron or electric iron while the pulp is still between the blotters. Run the iron over the surface of the blotting paper similar to ironing clothes. To put a smoother finish on the sheet run the iron directly on the paper.

INDUSTRIAL PAPER

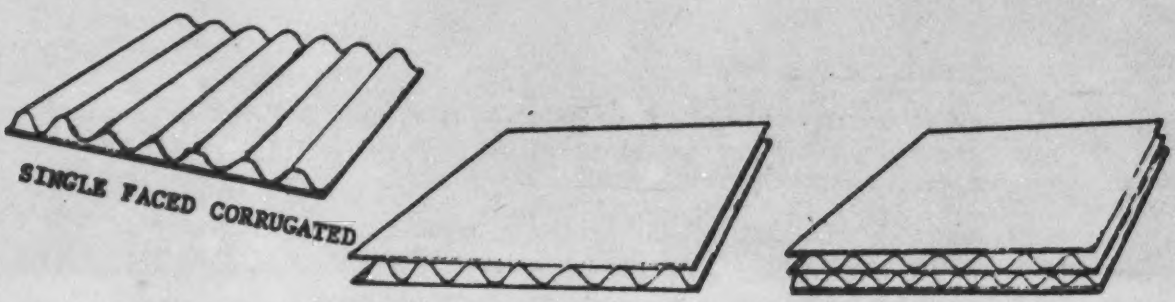
Industrial paper is all paper that isn't designed to be some type of writing paper. While industrial paper can be printed and written on, its main use is for 3-dimensional products such as packages used for storage and shipment. Other examples of industrial paper are: wrapping paper, paper towels, paper plates, paper cups, napkins, construction paper, cardboard, and paper clothing.

Paperboard

The basic raw material for corrugated boxes and products is paperboard. The basic machine used in preparing this paperboard is called a corrugator. This particular machine puts together the liners and the corrugated center, forming them to shape as they run through the corrugator. The corrugator machine is huge; some a city block in length, expensive to buy, install, house, and operate.



The most common corrugated board made has two liners, and a corrugated center, but more layers of corrugations are used when greater strengths are required. The liners and corrugations are glued together with fast setting adhesives. The composite structure called paperboard is a standard stock item which can be used for a variety of industrial packages.



Processing Paperboard

The design used for a particular package depends on the shape of the product to be packaged, the material it is made of, and how the product is going to be sent. If a large number of containers are to be made, a die-cutter will probably be needed. If only a few are needed, they could be cut with scissors or a razor blade.

The die-cutter is a very useful tool in producing packaging systems. With use of the die-cutter many packages can be sheared out in a short time and the scoring operation can be performed. Scoring is an impression or crease in corrugated or solid fiberboard to locate and facilitate folding.

After the packaging system has been laid out, cut, and scored, it is ready to be folded into the particular shape for which it was designed. Colorful printing on the outside of the package is often necessary if the packaging system is to be on display. For example, boxes for toys are colorfully designed. If the boxes were plain, no one would look at them; but since they are printed in an artistic manner, they catch the eye of the buyer. When printing is required, it is done while the paperboard is in flat sheet stock. When the packaging system is exposed to moisture conditions, it must be coated with wax or plastic materials. Coating will give the paperboard resistance to deterioration by moisture and will keep the contents dry. The steps in processing fiberboard into a particular packaging system are:

1. Lay out the package with drafting techniques to correct sizes and shape. Joints are allowed for as needed. Flaps and slots are allowed for and drawn in the layout.

2. The layout is cut out by hand tools or by a die-cutter.

3. Scoring is done with a hand roller or with a scoring rule mounted in the die-cutter.

4. The cut out paperboard is printed, usually with rubber plates.

5. The package is coated if it is to be moisture resistant.

6. Folding and fastening the package is the final step.

Texting packaging systems

Testing a packaging system is important to help decide how heavy and strong a package should be made. Some testing must be done to the package while the intended product is contained within. Major tests are: burst, puncture, impact, vibration, and compression.

In the puncture test the resistance of fiberboard to penetration is measured and the stiffness of the specimen is determined. In this particular testing procedure, a pyramidal metal point is driven through a specimen of fiberboard by the swinging action of a pendulum from which the point projects.

The crush test records the force required to crush the corrugations in a specimen of combined board. Pressure will be applied to the flat surfaces of the specimen and the load per square inch required to cause the corrugations to collapse is determined.

The impact test measures the resistance of a filled contained to shocks caused by dropping objects in certain ways (on corner, edges, faces, etc.) onto a solid surface. The test measures how well a container and its inner packaging (if any) will protect the contents against the handling encountered in shipping. This test will be tried from different heights.

The compression test involves the application of pressure applied by two flat surfaces of some type of mechanical device to opposite faces of a box, such as top and bottom, the two ends, or the two sides. Usually, the test is performed on individual empty boxes, and measurement is taken of the load applied in pounds and the deflection or deformation in one-tenth of an inch.

In all these tests the tolerances must be decided ahead of time so that it can be determined if the package passed the tests.

Figuring packaging costs

The price for the paperboard itself must be figured with the waste included. The fastening material whether glue, stitching, tape, or staples, has to be considered. Printing, assembly, coating, storage, and loading charges must also be included. Many industrial products are packaged in systems which cost as much as 20 - 30 percent of the product's selling price and some packages, such as prepared breakfast cereals or Avon products, far exceed the cost of the articles that are contained within.

CONSTRUCTION OF A PACKAGE

Construct a packaging system to hold the paper weight. The paper weight will be shipped by truck and kept in storage until removed and put on the shelf.

PAPER WEIGHT

Product "Weight" 16 oz.

Product not easily broken but can be misshaped by crushing

"Overall dimensions" 2" x 2" x 2"

PAPERBOARD ALLOWANCE
8" x 12"

Experiment with layout sketch

Product "Material" Lead base and polyester sphere

IDENTIFICATION CHART

PLASTICS	SPECIFIC GRAVITY	SOLVENT TEST					HEAT TEST	BURN TEST				PHYSICAL TEST
		Water	Toluene	Butyl acetate	Acetone	Cyclohexanone		Flame color	Smoke	Smell	Sound	
Styrene	Sinks		x				Softens	Orange flame Black smoke Smell like marigold				Rather brittle
ABS												
Acrylic												
Nylon												
Polyethylene												
Polyvinyl chloride												
Urethane foam												
Phenolic												
Butyrate												

IDENTIFICATION PROCEDURE

Nearly all plastic materials can be identified by subjecting them to the specific gravity test, solvent test, heat test, burn test, or the physical characteristics test.

Specific gravity test

Most plastics have specific gravity much the same as water, or about one. Plastics which float on water have a specific gravity of less than one while those which sink in water have a specific gravity greater than one. (Caution: This test does not apply to cellular materials because they all float if they are closed cell structures.) Be sure to push the plastics sample down into the water to avoid surface tension which will cause plastics to float even if their specific gravity is greater than one.

Solvent test

Some plastics can be dissolved by selected solvents while other plastics will not dissolve with any solvents. A series of five solvents which are very useful for identification purposes are: water, toluene, butyl acetate, acetone, and cyclohexanone. The plastics sample to be identified is submerged in the solvent 10 to 15 seconds. If the sample goes into solution, that is, turns syrupy and sticky, the solvent is dissolving the plastics. The plastics samples should be held with a tweezer and a new sample should be used for each solvent. Care must be taken to go through the above solvent order. No steps should be missed nor should a reverse order be taken.

Step 1 - Dip a small sample into warm water for 10 to 15 seconds. If it starts dissolving the sample will be polyvinyl alcohol.

Step 2 - Toluene - If the first sample did not dissolve, take a new sample, place it in toluene, and observe the results. If it dissolves the material is styrene, ABS, or polycarbonate.

Step 3 - Butyl acetate - If the second step did not affect the sample, take another sample and submerge it in butyl acetate. If it dissolves it is cellulose acetate butyrate.

Step 4 - Acetone - If the third step did not affect the sample take another sample and submerge it in acetone. If the sample dissolves it is cellulose acetate.

Step 5 - Cyclohexanone - If the previous steps have not affected the material take a new sample and submerge it in cyclohexanone. If the sample dissolves it is polyvinyl chloride.

If the plastics material is unaffected by these solvents, it is one of the thermosets or could be one of the following thermoplastics: acrylic, polyethylene, polypropylene, nylon, fluorocarbon, or acetal.

Burn test

The burning characteristics of plastics give a good indication of what the sample is. Some burn violently while others are slow burning or self-extinguishing. Some indeed will not burn at all. When burning a plastics sample, use a small piece and hold it with a metal tweezer.

Observe how it burns -

1. Color of flame?
2. Size of flame?
3. Flickering or smooth flame?
4. Type of smoke?
5. Does the sample melt and drip?
6. What kind of burning noise is there?

Detect the odor of the sample after extinguishing the flame -

1. Some smell sweet.
2. Some lack odor.
3. Some smell like rubber, burning wool, or rancid butter.

Heat test

This test will quickly indicate if the material is thermoplastic or thermosetting. An electric soldering gun can be pressed on the surface of the plastics material. If the material softens it is a thermoplastic but if it stays hard it is a thermoset.

Physical characteristics test

General appearance and feel of plastics can be useful in identification, but one should be cautious because feel and appearance can be deceiving. Some thin plastics sheets can be torn easily, while others are very tough to tear. Some plastics feel slick and waxy, while others seem to scratch easily.

TEXTILES AND FABRIC CONSTRUCTION

Using heavy colored paper and white vinyl glue, adhere twelve textile samples to heavy paper sheets as shown below. The textile samples will be cut to size with a metal template and scissors.

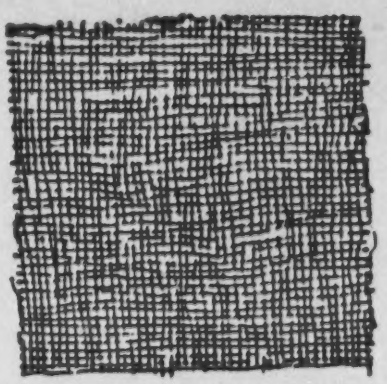
(Textile)

(Construction)

xx Glue xx
Fabric Care:
Fabric Uses:

Polyester
(Textile)

Double Knit
(Construction)



After the glue has had a few minutes to dry, fill in the spaces with the appropriate information.

...washable
Low heat resistance

Fabric Uses:
-*Where good drapability is required*

Textile samples you should have:

Polyester Double Knit	Felt
Fiber Glass Single Weave	Muslin
Fiber Glass Double Weave	Crepe
Fiber Glass Woven Roving	Burlap
	Ticking
	Vinyl, Supported
	Nylon
	Denim

NAME _____

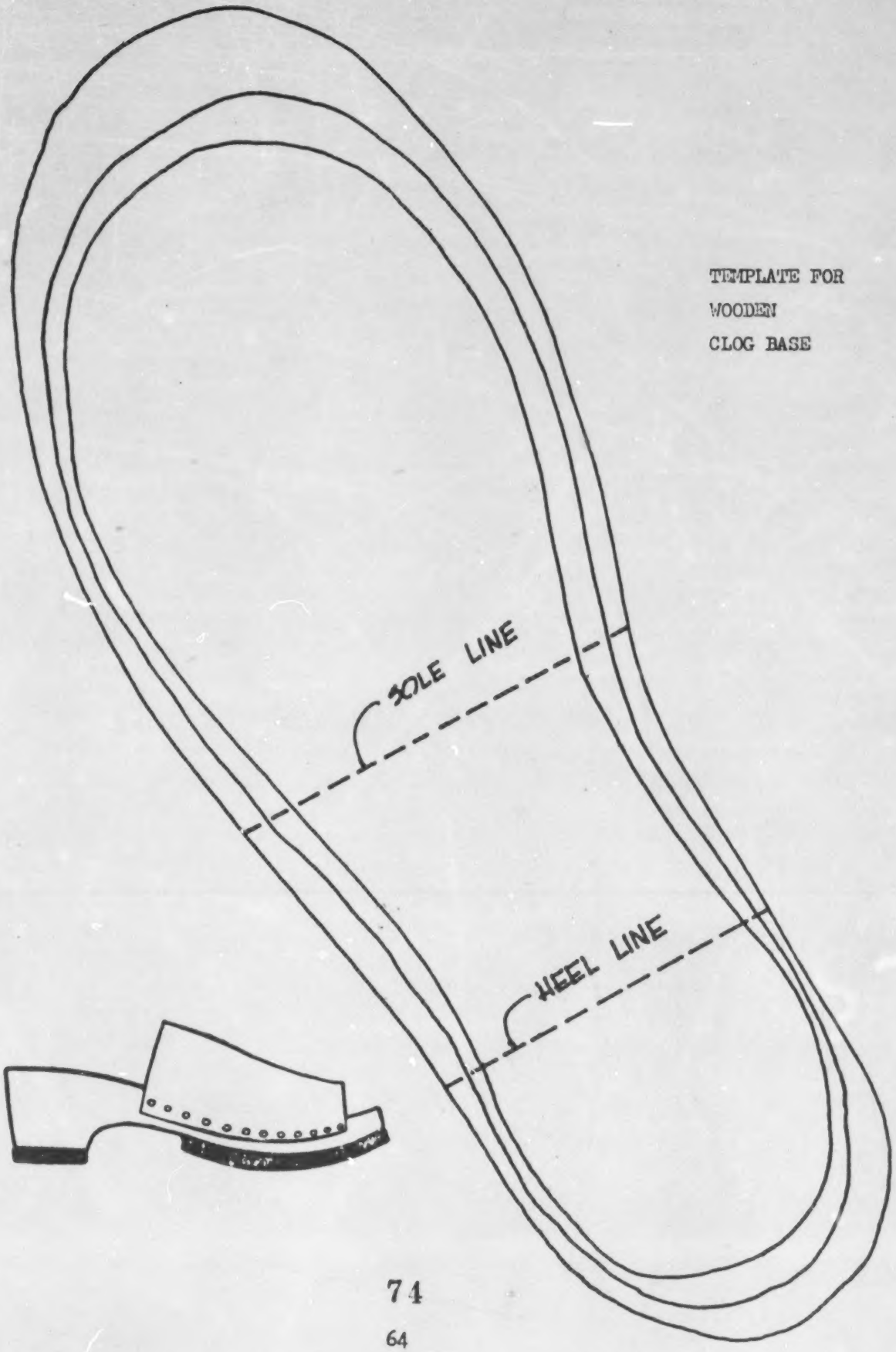
TEXTILES AND FABRIC CONSTRUCTION

(Textiles)	(Textiles)	(Textiles)
(Construction)	(Construction)	(Construction)
xx Glue xx Fabric Care: Fabric Uses:	xx Glue xx Fabric Care: Fabric Uses:	xx Glue xx Fabric Care: Fabric Uses:
(Textiles)	(Textiles)	(Textiles)
(Construction)	(Construction)	(Construction)
xx Glue xx Fabric Care: Fabric Uses:	xx Glue xx Fabric Care: Fabric Uses:	xx Glue xx Fabric Care: Fabric Uses:

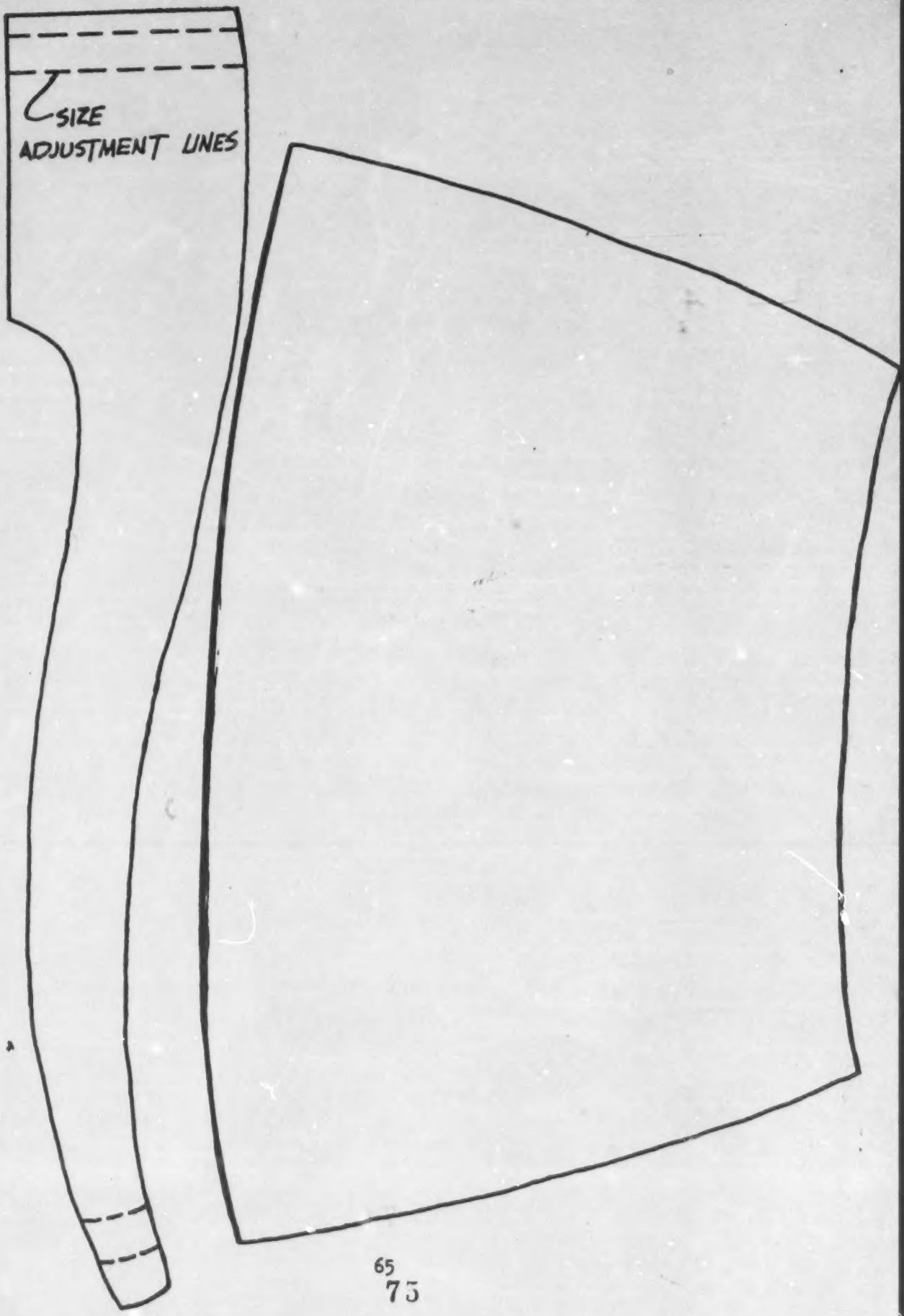
TEXTILE CHART

TYPES OF TEXTILES NATURAL	SOURCE	PROPERTIES	HEAT RESISTANCE	CARE REQUIRED	USES
1. Wool	Fleece of sheep	Elasticity, Resiliency Flexibility	High	Dry clean or hand wash	Carpet, Clothing
2. Silk	Insect, cocoon	Luxury fiber	High	Dry clean or hand wash	Clothing
3. Cotton	Cotton plant	Low cost, Easy care	Low	Machine washable	Clothing, Household
4. Hemp	Plant	Poor elasticity	Medium to low	Washable	Cordage, Rope, Tarpaulins
5. Asbestos	Mineral		High		Brake linings, Padding, Gloves
6. Jute	Plant	Least expensive	Medium to low	Washable	Carpet backing, Sacking, Bags
7. Flax	Plant	Strong, Irregular fiber	High	Washable	Linens
8. Speciality hair fiber	Animals	Limited availability	High	Dry clean	Clothing, Drapes, Blankets
9. Fiber glass	Mineral	Low flexibility	High	Hand wash	Curtains, Drapes, boats Industrial toolins

TYPES OF TEXTILES MAN-MADE					
1. Rayon	Cellulose from plants	Easy care, Absorbant	Low	Hand wash	Clothing, Home furnishings
2. Acetate (1952)	Cellulose from plants	Low strength, Resists mold	Low	Dry clean or hand wash	Clothing, Lining, Bedspreads
3. Nylon (1939)	Petroleum	Strength, Elasticity	Low	Hand wash	Hosiery, Tires, Cord, Clothing
4. Acrylic	Petroleum	Low density, High bulk	Low	Hand wash	Clothing, Carpets, Blankets
5. Dacon Polyester	Petroleum	Elastic, Strong	Low	Machine washable	Clothing
6. Vinyl	Petroleum	Easy care, Non-absorbent	High	Washable	Outdoor upholstery, Furniture, Drapes
7. Olefin fibers	Petroleum	Strong	High	Washable	Cordage, Seat Belts, Rugs



TEMPLATE FOR
WOODEN
CLOG BASE


SIZE
ADJUSTMENT LINES

ROCK IDENTIFICATION PLAQUE

Instructions: From the group of six stones given to you by the instructor determine the name of each stone and place it on the double "XX" beside the matching name given below. Some of the stones will need to be cleaned and finished slightly before they are mounted. After proper stone placement they will be "packaged" in place with a clear blister pack provided by the instructor.

XX SANDSTONE

Uses:

XX SLATE

Uses:

XX GRANITE

Uses:

XX MARBLE

Uses:

XX LIMESTONE

Uses:

XX SHALE

Uses:

ROCK AND STONE

Rock is a concretion of earthy or mineral matter; stone refers to small, weathered or water-worn fragments, or those portions of rocks which are shaped or dressed for buildings. Rock, natural in origin and inorganic in composition, is the solid portion of the earth's crust. The construction industry consumes more than half of the rock materials produced by mining in the form of crushed stone, dimension stone, and for cement, brick, tile, and insulation.

Sulfur, salt, and limestone, basic to the chemical industry; phosphates, nitrates, and potash, required by agriculture; and clay, which supports the ceramics industry, are all rock materials. Limestone, graphite, molding sand, and fireclay are very important to the steel industry. Some rocks are used for abrasives, electrical insulation, and filtration media. Rock, stone, and the minerals from which they are derived are the raw materials used for making glass, concrete, plaster, and ceramic products. The three main classes of rocks are igneous, sedimentary, and metamorphic.

Igneous rocks were once molten masses and through differing pressure amounts and cooling rates became either fine-grained rocks or rocks with large crystals. Lava rock, very glassy in appearance, is an example of a fine-grained igneous rock, while granite is the most popular example of igneous rock having a large crystalline structure.

Because of its dimensional stability, granite precision surface plates are used in machining and calibration laboratories. The rock hardness of granite is 7 as rated on Mohs scale from 0-10, which ranks it as one of the hardest rocks used for structural purposes.

Varied and stable colors constitute the beauty of granite. Because of this beauty, the primary uses for granite in order for importance are: (1) monuments and memorials, (2) buildings - as foundation blocks, steps, and columns, and (3) curbstones and paving blocks.

Sedimentary rocks, resulting from the decomposition of older rocks, are found on or near the earth's surface. Through forces of nature rocks weather, erode, or crumble into various sized particles. Some of these materials remain near the source, as sand in desert regions; while others are transported by water and settle on the bottoms of rivers and lakes. The sediment builds up and eventually hardens. Examples of this type of rock are: sandstone, limestone, shale, and gypsum.

Sandstone is very popular construction material used primarily as a building stone or concrete aggregate. Limestone is used in applications similar to those of sandstone, but also for soil conditioning and as a fluxing agent. Shale consists chiefly of clay in thin layers (actually called claystone when laminations are not apparent) and is used for ceramic products. Gypsum rock is the basis for most plasters used in construction of buildings and in the making of models and molds.

Metamorphic rock is igneous or sedimentary rock that has been changed (metamorphosed) to another composition and form through heat and pressures within the earth. The rock does not melt as it goes through the changes in composition and form. Slate, marble, and quartz are metamorphic rock.

Slate, found in a variety of colors, is a closed-pore rock with rigid characteristics. Roofing slates, mantels, steps, chalkboards, and billiard table tops are often made of slate. Marble is used primarily as a decorative stone because of its interesting color patterns. Statuary sculptures, exterior and interior walls of public buildings, washbasins, and electrical power panels are often made of marble. The cost of marble is high because about fifty percent is lost in mining operations. However, many new uses are being developed for the waste that comes from the quarries. Marble dust and marble chips are added to polyester resin to produce artificial marble headstones, vanity tops, and furniture items. When marble is used in this manner, it is referred to as cultured marble.

CUTTING ROCK AND STONE

When possible, rock and stone are shaped by breaking away unwanted portions by a process called induced fracture. With a sharp blow of a hammer along a scratched mark or line intentionally placed on the rock earlier, the rock breaks at the desired place. Brick layers and stone masons frequently use the technique of induced fracture.

When greater accuracy is required, stone may be sawed with an abrasive saw made of diamond; diamond is the hardest of all rock. These saw blades, costing many hundreds of dollars each, provide a smooth, finished surface.

Rock and stone may be cleaned, re-surfaced, or etched by sandblasting. Sandblasting is a process of eroding away materials by spraying a stream of sand under pressure. If a design or lettering is desired on the stone, a rubber template is placed over the stone prior to sandblasting. This is the process used for inscribing letters on gravestones and building cornerstones.

MOH'S HARDNESS SCALE

The Moh's hardness scale arranges ten rocks in order of ascending hardness as follows:

1. Talc
2. Gypsum
3. Calcite
4. Fluorite
5. Apatite
6. Feldspar
7. Quartz (marble)
8. Topaz
9. Ruby or Corundum
10. Diamond

The listed rocks, with known Moh's values, can be used to scratch other substances to determine the approximate Moh's number for the unknown material. A material will not scratch unless it is rubbed with a harder material than itself. For example, hardened steel can be scratched by quartz but not by feldspar; therefore, the approximate Moh's value for hardened steel is 6.5.

GLASS

Glass, a ceramic composed largely of silica, is a hard non-porous material with excellent tensile strength. When fine fibers of glass are carefully arranged, products exhibiting excellent flexural strength, such as fiberglass vaulting poles, skis, and boats, are possible. Normally, however, glass is considered a rather rigid and brittle material. Because of its non-crystalline structure and because it does not exhibit a definite melting point, glass is really a "stiff" liquid which becomes less viscour as the temperature rises.

While the primary component of glass is silica, obtained from high purity sand, other minerals in the form of oxides are added to glass in varying kinds and amounts to produce particular kinds of glass. Boron oxide, alumina, soda, potash, lime, magnesia, lead oxide, barium oxide, and zinc oxide are the principal secondary components of glass.

Soda-lime glass, commonly used for windows because of its low cost, contains 73.5, 21.3, and 5.2 percentages of silica, soda, and lime respectively. The forming temperature of 1200° - 1400° Farenheit, lower than for other types of glass, makes it possible to form soda-lime glass in school laboratories and in home ceramic kilns.

Two glasses having special engineering properties are borosilicate (Pyrex), with a low coefficient of expansion, and quartz glass, with excellent resistance to chemicals; both have excellent resistance to spalling or cracking caused by severe changes in temperature. Quartz glass transmits ultraviolet radiation very efficiently, but is difficult to process because of its high forming temperature (greater than 3000° F).

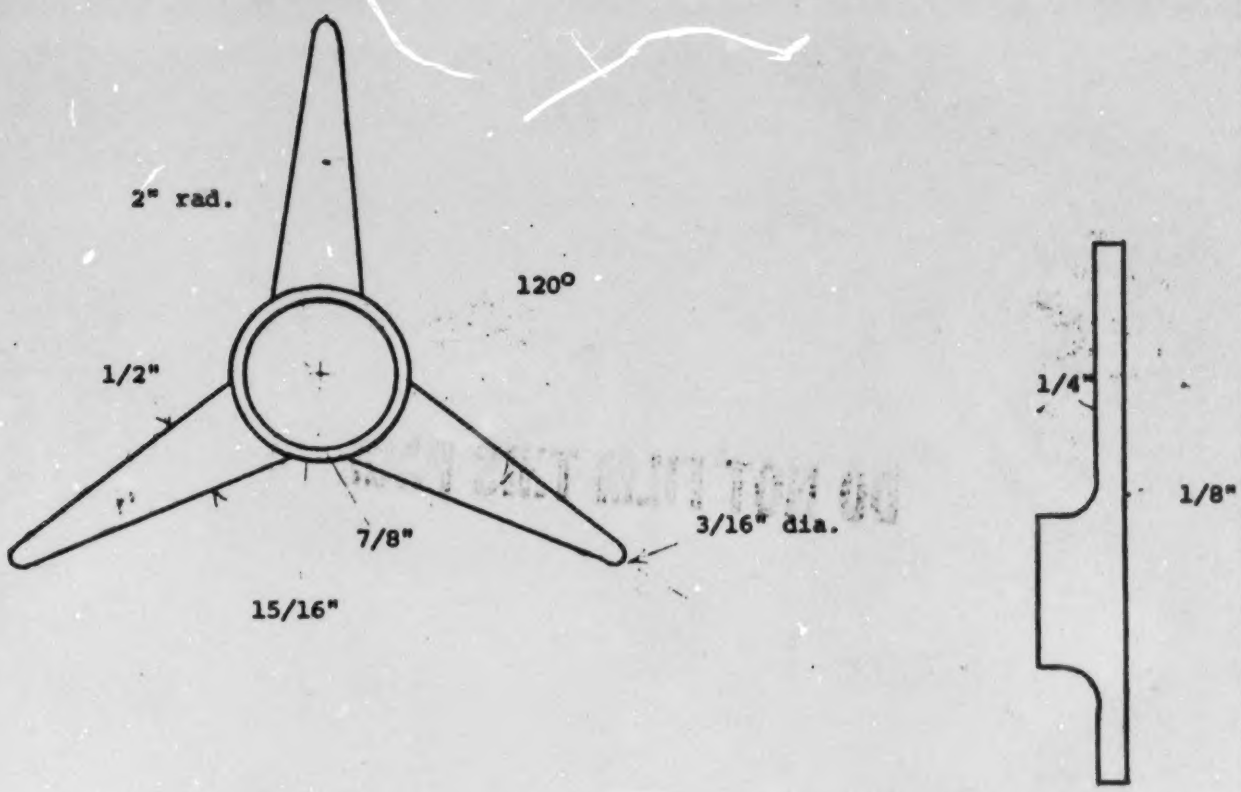
Glass has a remarkable range of uses. To the building contractor and toolmaker, glass is a structural material. To the engineer, glass is an electrical insulator and light transmitter; and to the packager, glass is a container material for foods and drugs.

By the addition of metals and metal oxides, glass may be colored. Nickel oxide imparts a color range from yellow to purple depending upon further additives. With boric oxide the color is yellow; with potash, reddish-violet; with soda, brownish-violet; and with the addition of lead silicate, the color is purple. A wide spectrum of colored glasses is possible by varying the type and amount of additives; however, while beautiful, colored glass is very expensive.

When forming glass, soda-lime glass will be used as an example, the glass must be inserted into a mold often made of stainless steel. The mold is then placed into an oven at room temperature. While leaving the oven door open slightly, the oven should be turned on. After the temperature has reached 1000° F, the oven door should be closed. The oven should be turned off when the temperature reaches 1400° F, but the oven door should remain closed until the oven cools to room temperature.

The whole process of forming glass may take 12 to 24 hours and rarely can the process be hurried without spalling the glass. Forming glass is difficult and time consuming unless elaborate production systems, feasible only when high quantities of products are needed, are available. When large quantities of parts are not needed, such as in aircraft production, plastics materials, of having greater formability at lower temperatures, are often used for glazing purposes.

PAPERWEIGHT



PRODUCT DEVELOPMENT

Lead Weight

1. Introduce the idea
2. Construct hard mockup
3. Plaster splash (Female mold)
4. Ram and cast permanent mold of aluminum (Green sand or shell mold)
5. Machine permanent mold

Ball

1. Introduce to plastics casting (polyester)
2. Mix polyester resin and catalyst
3. Pour into flasks (glass)
4. Add decorative systems (color, glitter)
5. Cure parts
6. Remove from mold (break glass flask)

Assembly

1. Position ball on base
2. Bend prongs into position

UNIT III - FORMING MATERIALS

COURSE: MATERIALS AND PROCESSES

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
Unit III - Forming Materials	The student will be able to explain the four concepts of shaping: (a) forming, (b) separating, (c) combining, and (d) finishing. The student will be able to discuss the following types of forming: (1) Casting and molding - the materials generally liquefy or become semi-liquid during casting and molding (a) Cold casting materials - casting materials that are liquid at room temperatures and harden in room temperatures - gravity is sufficient pressure (b) Hot casting materials - casting materials which liquefy when heated and harden in room temperatures - gravity is sufficient pressure (c) Molding - forming materials with pressures higher than gravity in matched molds or dies usually made of metal (2) Compressing and stretching - forming materials (solids, sheets, or bars) at room or elevated temperatures. Both compressing and stretching occur simultaneously in most operations	Discussion-demonstration. The student will become familiar with the products that will be manufactured in this unit by observing the product and pictures of production sequences.	(13) p. 112-144
I. Stretch Forming	The student will be able to discuss the principles and common materials used in the stretch forming process. The student will be able to describe:	Discussion-demonstration. The student will produce the stretch forming tool and will complete the entire stretch formed fruit bowl prior to engaging in any other laboratory activity.	(13) p. 187-204

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
	(a) stretch forming sheet metal, and (b) stretch forming textiles	Supplies: Sketching paper 3/4" x 8" x 10" wood Polyester double knit cloth with good drapability Carpet tacks Tack hammers Scissors Sandpaper Paste wax Polyester resin with catalyst 1" inexpensive stain brushes Lacquer thinner White polyvinyl glue Disposable cups ½" x 3" wooden dowel Equipment: Band saw Drill press Disc sander	
II. Rotational and Blow Molding	The student will be able to explain the following: (1) Rotational molding - molding completely closed hollow objects of plastics and rubber by rotating raw materials inside a heated mold (2) Blow molding - molding hollow objects by blowing a heated tube (parison) of plastics or glass against the walls of a two-piece female mold	Discussion-demonstration. After having observed demonstrations, students will form a wax fruit and polyethylene bottle by rotational molding and blow molding respectively. Supplies: Candle wax with dyes Petroleum jelly parting agent 3/4" OD polyethylene tubing Fruit molds Blow molding device Equipment: Air compressor Oven Rotational molder (optional)	(13) p. 560-561

COURSE: MATERIALS AND PROCESSES

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
III. Drape Forming Reinforced Plastics	The student will be able to discuss the following: (1) Principles of reinforced plastics (2) Systems for forming reinforced plastics (3) Characteristics of reinforced plastics	Discussion-demonstration. Student activities are as follows: (1) Given four descriptions the student will select an appropriate definition of reinforced plastics. (2) The student will describe the characteristics of reinforced plastics products. (3) The student will match description of processing methods with corresponding names. (4) Given the necessary tools and supplies the student will produce a model boat hull comprised of two layers. Supplies: Boat hull mold Fiber glass cloth Polyester resin with catalyst 1" stain brusnes Polyester dyes Paste wax Wiping rags Scissors Lacquer thinner Weighing scales Disposable cups and stirring sticks Equipment: Circular saw or drill press horizontal saw	(17) p. 50, 88-94, 191-198 (7) p. 14, 27, 39
IV. Thermoforming Thermoplastics	The student will be able to explain the following: (1) Thermoforming - forming thermoplastic sheet stock by heating until plasticized and forcing (vacuum or compressed air) against	Discussion-demonstration. The student will thermoform a model boat deck of styrene plastics sheet. Supplies: .040" - .060" styrene sheet Thermoforming male mold	(7) p. 12-14, 40, 138, 271 (17) p. 82-94, 140-156

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
	a form until cold. (a) Processing methods: vacuum seal, cavity vacuum, ramming using male and female mole (b) Nature of thermoformed parts	Sheet clamping frame of wood Equipment: Vacuum forming table Drill press with horizontal circular saw	
V. Casting Metals	The student will be able to discuss the following things about foundry practice: (1) Hot casting (2) Patterns (3) Types of molds (4) Pouring procedures	Discussion-demonstration. The student will cast a model boat dagger board of aluminum with a match plate and green sand. Supplies: Match plate pattern Green foundry sand Flasks Ramming tools Aluminum ingots Hack saw Curved tooth files 1/2" twist drill Crucible Safety clothing Tongs Pyrometer Flux Skimming tools Equipment: Drill press Foundry furnace	(13) p. 112-121
VI. Foaming Cellular Plastics	The student will be able to explain the following: (1) Cellular molding (2) Purpose and process of foaming cellular materials (3) Expanded polystyrene (4) Foaming urethane	Discussion-demonstration. Floatation and adhesion qualities of urethane resin will be shown as students assemble the model boat hull, deck, and dagger board. Supplies: Boat hull, deck, and dagger board Urethane foam components Disposable cups	(17) p. 95-97, 177-183

COURSE: MATERIALS AND PROCESSES

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
		Stirring sticks Weighing scales Alcohol for cleaning	
VII. Forging Metals	The student will be able to define forging and discuss the following: (1) Characteristics of a forged part (2) Systems of forging (3) Forged products	Discussion-demonstration. The student will forge a screwdriver blade with a drop forge and properly temper the screwdriver blade by observing the temper colors. Supplies: 1/4" medium carbon drill rod Abrasive cloth Hacksaw Tongs Asbestos gloves Match plate for handle Aluminum ingot Vinyl coating (optional) Curved tooth files Equipment: Gas fired forge Drop forge Pedestal grinder	(13) p. 151-159
VIII. EXPLOSIVE FORMING	The student will be able to discuss the value of an explosive charge in forming metal.	Discussion.	(13) p. 184-185
IX. Metal Spinning and Stamping	The student will be able to explain the process of metal spinning and stamping.	Discussion-demonstration. The student will stamp and spin an aluminum coaster. Supplies: .030" - .050" 1100 series annealed aluminum Forming chuck and follow block for spinning Round nose spinning tool Cutoff tool for spinning Form blocks for metal stamping	(13) p. 171-177

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
		Beeswax for lubrication Abrasive cloth Equipment: Hydraulic press Wood lathe	
X. Contour Lamination	The student will be able to explain the properties and processes of contour lamination with woods. The student will be able to define: (a) Contour lamination - pressing wood layers, with adhesive between the layers, to desired shape with matching male/female forms until the adhesive has cured	Discussion-demonstration. The student will make a salad fork by the contour laminating process. Supplies: Veneer White vinyl glue Wax paper Glue brushes Matching wooden molds Abrasive paper Finishing oil Hand screw clamps Files Equipment: Band saw Jig saw	(10) p. 372-382 (11) p. 51
XI. Casting and Forming Imitation Glass	The student will be able to discuss the following: (1) The difficulties of glass forming and coloring (2) The development of polyester and acrylic glass synthetics	Discussion-demonstration. The student will form acrylic by draping over a male form and will cast a synthetic stained glass window of polyester. Supplies: 1/10" - 1/8" clear acrylic sheet Drape forming tool Polyester resin with catalyst Stained glass window molds Aluminum filled epoxy Parting agents Equipment: Oven Band saw	

COURSE: MATERIALS AND PROCESSES

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
XII. Casting Plaster	The student will be able to discuss the properties of cured plaster and procedures for processing it into desired shapes.	Discussion-demonstration. The students will make a white plaster mold, for casting chessmen of slip clay, by casting against a chessmen master tool. Supplies: White plaster Mold masters Petroleum jelly Plastic mixing containers Pneumatic mechanical mixer Old wood chisels Putty knives for clean-up Equipment: Water sink with plaster trap	(13) p. 141-142
XIII. Casting Slip Clay	The student will be able to discuss the following: (1) Methods of clay forming (2) Slip casting (3) How to turn clay into a ceramic	Discussion-demonstration. The student will make chessmen by the slip casting procedure. Supplies: White plaster molds Slip clay Dump buckets Trimming knives Equipment: Ceramic kiln Ventilated storage shelving	(22) p. 248
XIV. Injection Molding	The student will be able to explain the process of injection molding.	Discussion-demonstration. The student will injection mold polystyrene checkers, if equipment is available. Supplies: Red and black polystyrene pellets Silicone parting agent Gate cutters Small file Checker injection mold Equipment: Injection molding machine	(13) p. 557-560 (17) p. 66-85

UNIT IV - SEPARATING MATERIALS

COURSE: MATERIALS AND PROCESSES

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
Unit IV - Separating Materials	The student will be able to discuss how materials are shaped by forming, separating, combining, and finishing. The student will be able to discuss the following things about the separating process: (1) Separating primary materials - materials much like they are found in nature; these materials have had little or no industrial processing (2) Separating secondary materials - those materials which have been industrially processed into standard stock	Discussion-demonstration. Student activities are as follows: (1) The student will match descriptions of separating processes with the corresponding process name. (2) The student will recall the descriptions of primary and secondary materials. (3) The student will indicate at least four types of separation, both from primary and secondary materials. (4) The student will become familiar with products manufactured in this unit by observing the product and pictures of manufacturing sequences. Supplies: Chess cabinet, including polystyrene foam liner, checkerboard, and laminate lid Printed circuit board for optical lamp Permanent casting mold (produced by machining an aluminum casting)	(13)
I. Millwork: Woods	The student will be able to explain the following operations done of millwork: (1) cutting, (2) surfacing, (3) joinery, and (4) smoothing. The student will be able to discuss the woodworking tools and machines used for millwork.	Discussion-demonstration. The student will do the millwork required to manufacture a wooden chess cabinet according to specifications. Supplies: Sample wood for demonstration of cuts Dado blades (for rabbet joints and dado) 1" x 9" rough stock - Philippine mahogany Sandpaper Bar clamps	(11) p. 129, 180, 192 (10) p. 221, 284, 313 See Appendix II-p. 85-87

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
		White polyvinyl glue Glue brushes ½" fir plywood Linseed oil for finishing Claw hammers 3 penny finish nails Nail set Equipment: Jointer Router Surfacer Circular saw Radial arm saw Belt sanders Vibrating sanders See Appendix III for additional information on the construction of the chess cabinet.	
II. Thermal Cutting	The student will be able to define thermal separating and its following process: (1) Hot wire (2) Oxy-acetylene cutting (3) Arc cutting	Discussion-demonstration. The student will cut polystyrene foam to chess cabinet size. The student will also be given a chance to cut through plate steel with an oxy-acetylene cutting torch. Supplies: Cellular polystyrene foam liner 3/8" steel plate Equipment: Hot wire cutter Oxy-acetylene outfit with cutting attachments V8 E6011 electrode or special arc cutting electrode (optional)	(17) p. 25, 26, 97 (3) p. 3, 9

COURSE: MATERIALS AND PROCESSES

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
		225 ampere arc welding machine (optional) Proper number of goggles and helmets	
III. Shearing and Induced Fracture	The student will be able to discuss the shearing method of separating materials and its applications.	Discussion-demonstration. The student will shear plastics sheet to required size and quantity for the checker board. Supplies: Variety of hand shears .060" ABS sheet (white and black colors) Bottle cutting machine Bottles Equipment: Squaring shears Floor shears Curved shears Notching shears See Appendix III for information on "Checkerboard Construction".	(13) p. 446 (17) p. 102 See Appendix III-p. 88
IV. Machining	The student will be able to discuss the following things: (1) Definition of machining (2) Characteristics of machine parts (3) Basic types of machining (a) Drilling (b) Turning (c) Milling (d) Shaping (e) Grinding	Discussion-demonstration. A permanent aluminum mold, designed for casting a lead paperweight, will be machined from a casting and a 1/4" plate. Supplies: 1/4" aluminum plate Aluminum casting (made from a plaster pattern constructed earlier) End mill cutters Single point fly cutters 5/6" twist drill Hold down clamps for mill Mill files	(13) p. 308, 319, 343, 389

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
V. Cutting with Abrasives	The student will be able to define the term: abrasive. The student will be able to discuss the following types of abrasive materials: (1) Diamond (2) Silicone carbide (3) Aluminum (4) Flint (5) Garnet (6) Emery cloth (7) Steel wool (8) Pumice stone (9) Crocus cloth	Equipment: Vertical milling machine Drill press Band saw Discussion-demonstration. The student will construct and trim the chess cabinet lid. Supplies: Decorative laminate with wood grain pattern Contact cement 1/4" tempered masonite 8" - 10" abrasive cutoff wheel Abrasive paper Cement brush Lathe bit Abrasive saw blade Equipment: Circular table saw Pedestal grinder See Appendix III for procedure of the construction of chess cabinet lid.	(13) p. 391-399 See Appendix III-p. 89
VI. Chemical and Electrical Etching	The student will be able to explain the following things: (1) Definition of etching (a) Reasons for etching (b) Types of etching (2) Printed circuitry (a) Physical properties required for printed circuit materials (b) Electrical circuit history (c) Composition of printed circuit boards	Discussion-demonstration. The student will produce a printed circuit board by chemical etching for the optical lamp. Supplies: Developer solution Etching solution Stripping solution 3 1/4" x 6" pre-sensitized circuit boards Metal trays Plastic trays Contact frames Negatives Exposer light or sunlight	(15)

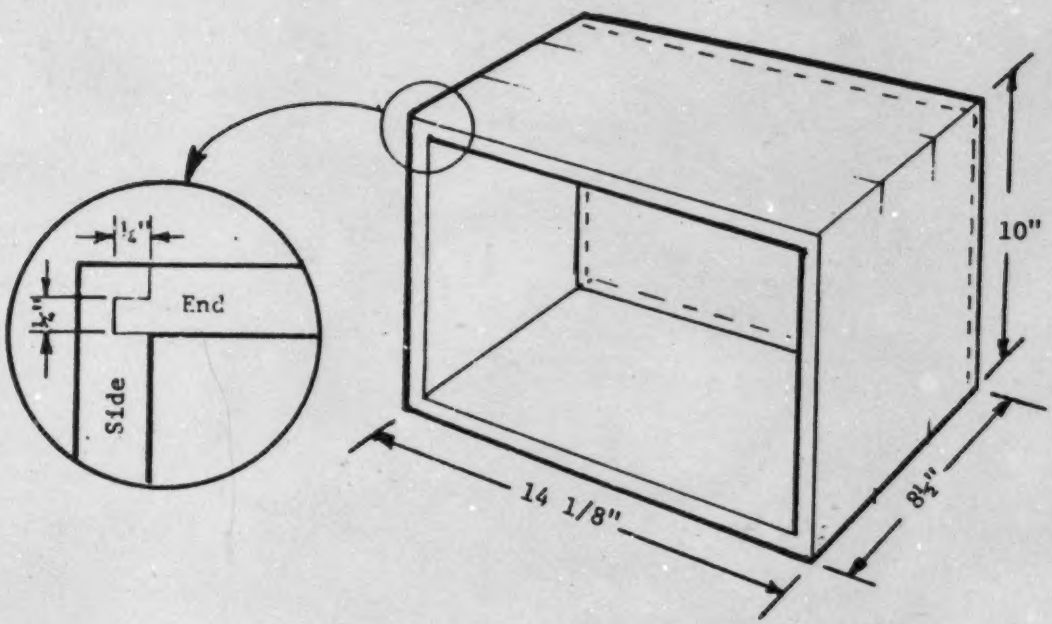
APPENDIX III

CONSTRUCTING

NAME_____

CONSTRUCTING THE CHESS CABINET

Materials Needed: ½" fir plywood (sound 2 sides)
1" x 9" Philippine mahogany (rough dimensions)
3 penny finish nails
Wood grain decorative laminate
¼" tempered hardboard (Masonite)
White vinyl glue



Mahogany Preparation

1. Surface stock to ½" thickness with surfacer.
2. Plane one edge with a jointer.
3. Rip to 8½" width with circular table saw.
4. Cut ends (9½") and sides (14 1/8") to length with radial arm saw.
5. Cut rabbet and dado joints (¼" x ¼") with circular table saw.

NAME_____

Bottom Construction

1. Cut ½" fir plywood (9" x 13 1/8") - make three pieces. Be sure to cut identical pieces with square corners.

Gluing and Clamping

1. Trial assemble ends, sides, and one plywood bottom. Work out clamping procedure with plywood bottom being flush (even) with the opening.

2. Disassemble and spread glue on all joint areas. Use white vinyl glue.

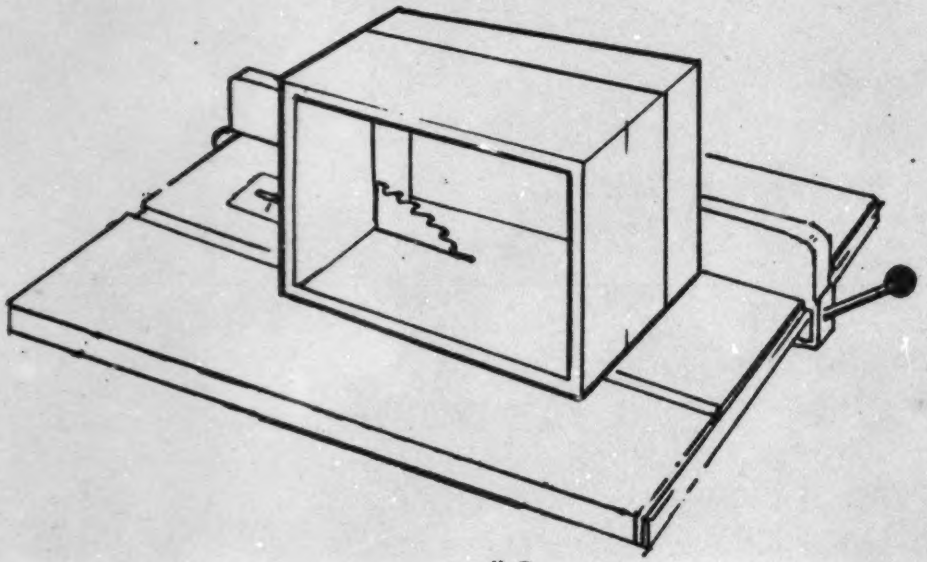
3. Clamp the ends, sides, and bottom with bar clamps and nail bottom with two 3-penny finish nails on each of the four surfaces.

Sectioning the Box

1. After the glue has dried, remove the clamps.

2. Clean up the box with a belt sander, making sure to blend the joint areas.

3. Separate the box into three sections with the table saw. The bottom is to be 2½" deep and each of the two upper sections is to be 2 3/4" deep.

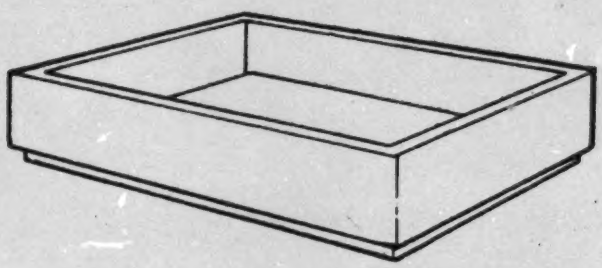


NAME_____

Placing Bottoms into Upper Sections

1. Chamfer (1/8" x 1/16"), using a disc or belt sander, lower edge of the remaining two pieces of plywood.

2. Insert each piece into its corresponding section by leaving the chamfer race protruding 1/8" beyond the section opening. Do this before applying any glue.



3. Remove bottoms and glue with white vinyl glue. Insert into opening to the desired depth and place two nails in each of the four surfaces.

4. Set all nails with a nail set.

5. Fill nail holes with wood putty.

Finishing the Chess Cabinet

1. Hand sand the cabinet on the outer sides and ends thoroughly, but only moderately on the inside.

2. Rub on an oil finish on the outside only.

3. Glue in polystyrene foam liners with white vinyl glue.

4. Brush coat the inside of each section with slow drying colored paint. Match the paint color with the flocking you have chosen.

5. Dump flocking into each section while the paint is still wet and place a plywood sheet over the box; shake the box vigorously in all directions.

6. Remove plywood sheet and dump out all excess flock. Save the excess flock.

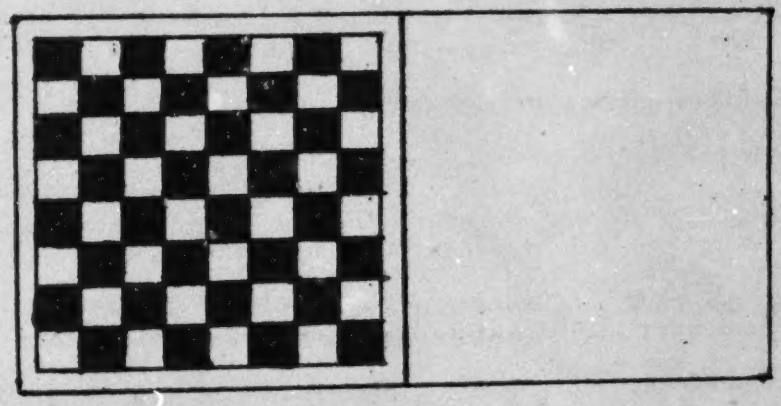
NAME_____

CHECKERBOARD CONSTRUCTION

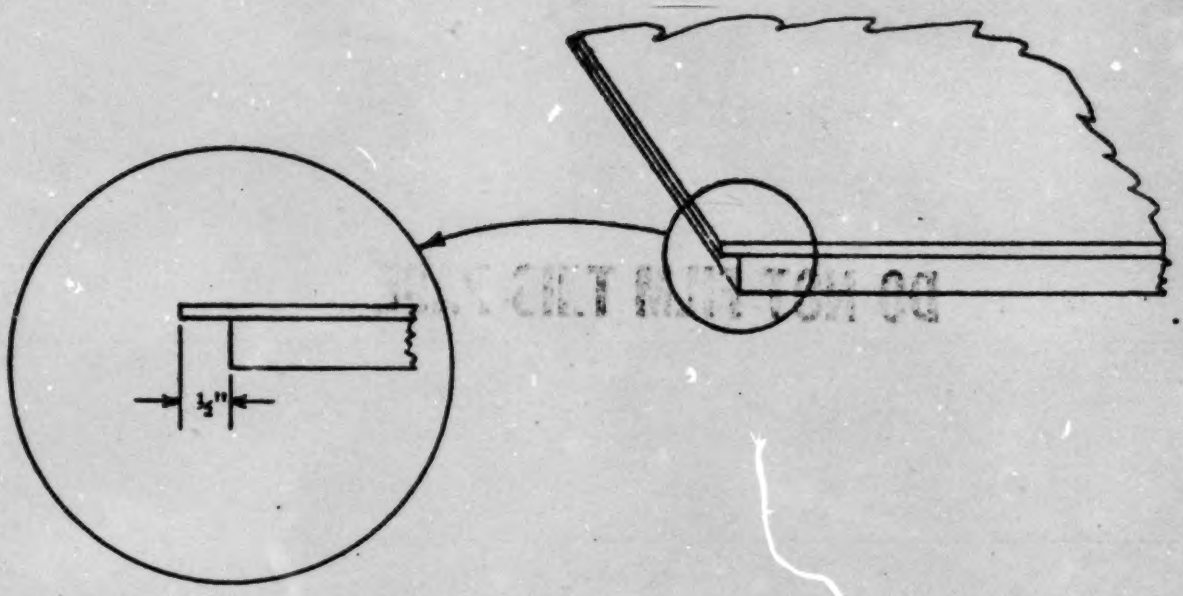
Materials Needed: .060" ABS plastics - white and black textured sheets
1/8" tempered hardboard
Contact vinyl paper with simulated wood grain
2" wide cloth air-conditioning tape (duct tape)
Contact cement for tile adhesion.

Procedure

1. Saw 1/8" hardboard 6 1/2" x 13". You will need two pieces.
2. Shear plastics sheet into 1 5/8" squares. You will need 32 white and 32 black squares. Be sure all pieces are square.
3. Lightly sand all surfaces to be bonded with fine sandpaper and wipe clean with alcohol.
4. Apply contact cement as instructed by the container label.
5. Place plastics squares into position carefully.
6. Place the two board halves together in an upside-down position and apply one strip of duct tape along the joint.
7. Cover the entire back with contact vinyl.



CONSTRUCTION OF CHESS CABINET LID



Procedure

1. Cut 1/4" tempered hardboard 8 7/8" x 13".
2. Cut decorative laminate 9 7/8" x 14".
3. Turn decorative laminate upside down and place the 1/4" hardboard upon the laminate. Position in the center and mark laminate with a lead pencil.
4. Lightly sand all areas to be joined and wipe clean with alcohol.
5. Brush contact cement on all faces to be joined and allow drying time.
6. Adhere the 1/4" hardboard and laminate by pressing the two glued surfaces together. Be sure to position the hardboard carefully by using the pencil line drawn earlier.

UNIT V - COMBINING MATERIALS

COURSE: MATERIALS AND PROCESSES

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
Unit V - Combining Materials	The student will be able to discuss the following things about combining materials: (1) Its purpose and types (2) Combining or mixing ingredients (3) Fastening systems for solids (4) Mechanical fasteners	Discussion-demonstration. The student will become familiar with the products that will be produced in this unit by handling the products and observing pictures of manufacturing sequences. Producing products by combining materials - student activities to be completed in this unit are: (1) Adhesion, cohesion, and mechanical fasteners - metals fastening systems display (2) Adhesion, cohesion, and mechanical fasteners - covered wagon made of wood (3) Mechanical fastening of textiles - cloth back pack (4) Tying rope knots - display plaque (5) Mixing ingredients - call attention to plaster, clay, and concrete products produced earlier (6) Soldering components - printed circuit board See Appendix IV for student activity lessons and reading on combining materials. *The completion of this unit will take several days.	(1)

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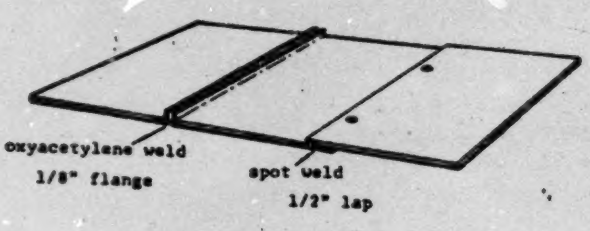
APPENDIX IV

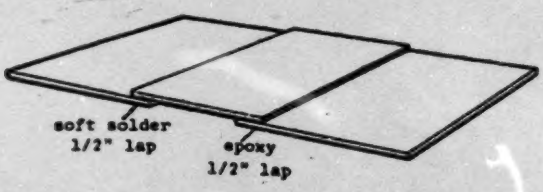
COMBINING MATERIALS

FASTENING SYSTEMS FOR METALS

COHESION - mild steel
one piece - 16 gauge x 2" x 5"



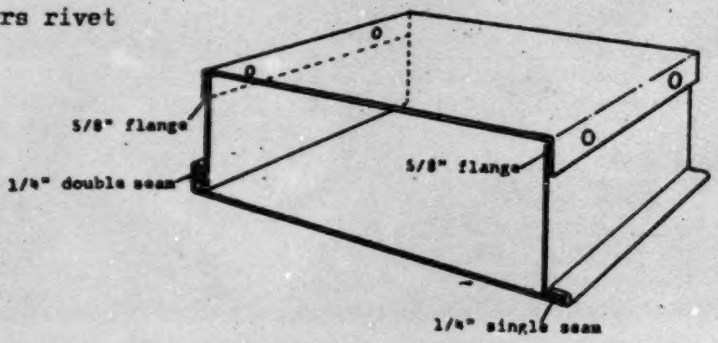
ADHESION - mild steel
one piece - 26 gauge x 2" x 5"



MECHANICAL FASTENERS - mild steel
two pieces - 26 gauge x 2" x 5"
two pieces - 26 gauge x 2" x 1½"

Non-threaded fasteners
1. Pop rivet
2. Tinners rivet

Threaded fasteners
1. Self tapping
2. Machine screw



COMBINING METALS

There are many ways in which metals can be combined into products, but all fastening systems can be classified by three general methods of cohesion, adhesion, and mechanical fasteners.

COHESION (Welding)

Welding is a fastening method by which metals may be joined by increasing the temperatures of the work pieces to their fusion points and allowing the molten pools formed to flow together and solidify. The methods may vary in the source of heat in dozens of different welding processes that are currently being used.

All metals are weldable provided that the proper process and technique are used. However, it is very important that the definition of welding given above is understood by the person attempting to weld so that the process will have a greater chance of being successful. Methods of welding are:

Arc welding

The basic principle of all arc welding is that the electrical resistance of an air gap in the circuit will cause an intense heat that will melt metal in the immediate weld area.

The operator has to make many decisions before he can complete a successful weld:

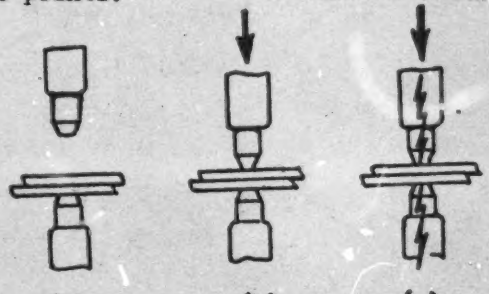
1. The electrode type must match the work according to kind of material, position of weld, and kind of welder.
2. The machine must be set for proper amperage according to kind of electrode and position of weld.
3. The arc length must be regulated to control heat zone and amount of bead deposit.
4. The speed of travel and manipulation of electrode must be controlled for correct fusion.

Resistance welding

Spot welding is one of the several forms of resistance welding and is often used to fasten sheet metal products. The principle of spot welding is that the resistance of the work piece to the current flow at the contact points cause the metal to heat to a plastic state. When pressure is applied to the contact points it causes a fusion weld between the two surfaces in their plastic state in the local area of the contact points.

Spot welding is done:

a. Sheets are placed between tips
b. Pressure is applied to the sheets
c. Electric current causes sheets to weld by fusion



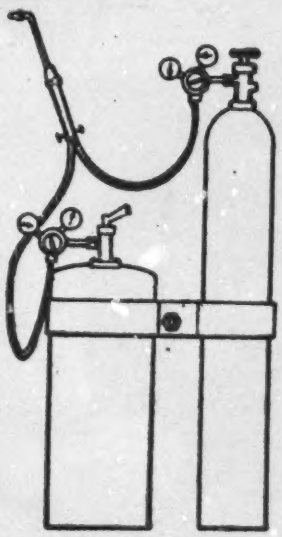
The advantages of resistance welding are fast production, very little warpage, and uniform welds.

Oxy-acetylene welding

Acetylene gas and compressed oxygen in proper ratio, capable of producing 6300°F temperatures, have long been used as a portable supply of heat for many welding purposes. The oxy-acetylene welding unit is comprised of the two steel bottles which hold the gases, pressure regulators for each bottle, hoses, and a torch.

A keen eye and well coordinated hands are required of the operator, for the melted puddle must be carefully controlled to obtain proper weld penetration. When additional metal is required to build up the weld joint, a filler rod is used. This filler rod must be inserted into the puddle and removed repeatedly with careful timing.

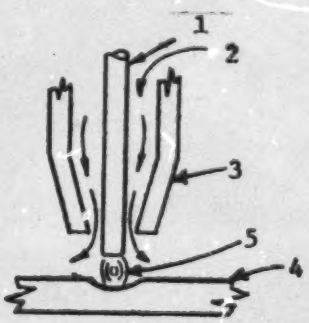
There are many other uses of oxy-acetylene heat such as: heat treating, hard soldering (brass, bronze, and silver), soft soldering, hard surfacing, and flame cutting.



OXY-ACETYLENE WELDING OUTFIT

Inert gas arc welding

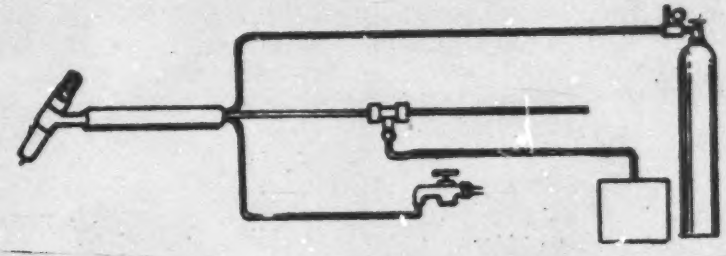
When atmosperic air is allowed to reach hot metal, reactions take place that are harmful to the weld. This contaminating air can be shielded from the hot metal with inert gases such as carbon dioxide, helium, and argon.



1. Electrode
2. Inert gas
3. Nozzle
4. Base metal
5. Arc

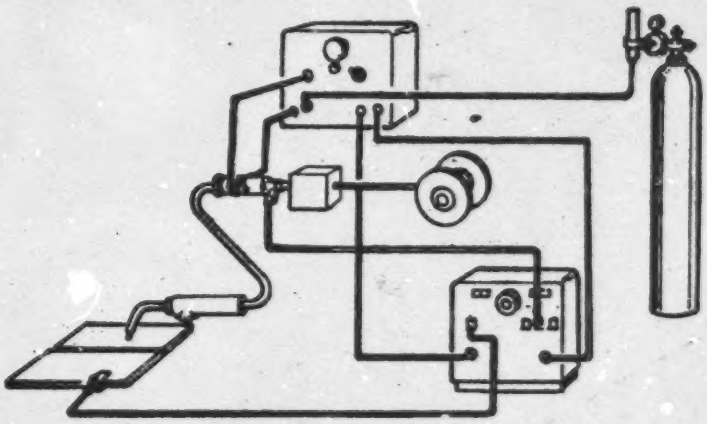
The two principal types of inert gas arc welding are tungsten inert gas welding (TIG) and metallic inert gas welding (MIG).

TIG welding, when done manually, is a similar process to that of oxy-acetylene welding. A filler rod is held in one hand and the TIG torch is manipulated with the other hand. The tungsten electrode must be properly shaped; kept clean, and held the correct distance from the puddle. This electrode is non-consumable, that is, it does not melt and become part of the weld.



TIG WELDING

MIG welding differs from TIG welding in that the electrode is consumable and becomes part of the weld. The electrode is a spool of wire that feeds into the arc at the proper rate of speed.



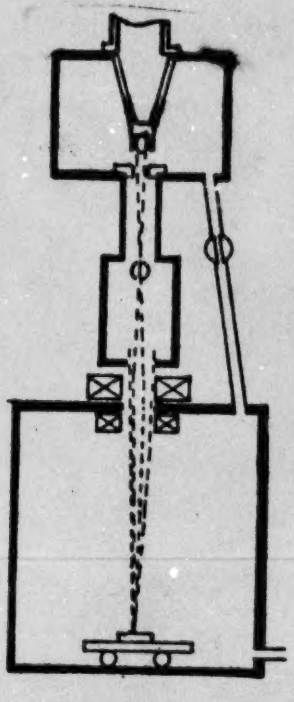
MIG WELDING

Since the inert gases shield away contaminating air from the puddle, high quality welds are possible even for metals which are difficult to weld.

Electron beam welding

Electron beam welding is performed in a vacuum while directing a concentrated stream of high energy electrons into the metal joint.

This process is expensive and, therefore, is reserved for exotic welding tasks. A very narrow weld bead with phenomenal depth of penetration is produced by electron beam welding.

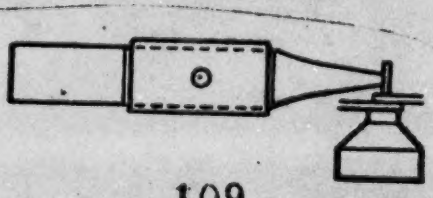


ELECTRON BEAM WELDING

Ultrasonic welding

The constant variable in all metal welding is heat and when heat is generated by high frequency sound the process is called ultrasonic welding. The unique features that distinguish ultrasonic welding from other welding systems are:

1. Only the contact surfaces of the base materials reach high temperatures; hence, there is little deformation of welded components.
2. A rather small clamping pressure is required; hence, there is little deformation of welded components.
3. No gases are present in the welding process; hence, no porosity occurs.
4. Some dissimilar metals may be ultrasonically welded.
5. Welding is possible even when the joint is not thoroughly clean.
6. The whole process often takes less than one second of time.



ULTRASONIC WELDING

ADHESION (Metal Bond)

The chemical industry has given the world many adhesive materials that are used to reliably fasten metal assemblies. Most adhesive materials used for metal bonding are thermosetting plastics.

It should not be assumed that adhesive bonding will replace welding, riveting, and other mechanical joints; however, it has made inroads in the metal combining areas. In the metal-to-metal bonding science, a strange fact evidenced is that psychological difficulties of overcoming prejudices, fear, and hesitation are greater than technological difficulties.

Among the advantages of bonding are simplified design and production techniques, lighter parts with configurations not otherwise possible, and improvement in strength characteristics for certain applications.

Adhesives

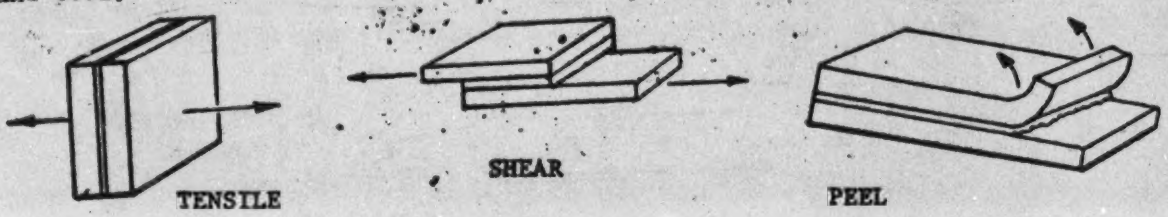
Many substances of different chemical structure may, under appropriate conditions, hold materials together by surface attachment; yet, not all of them can be regarded as adhesives.

For example, if water between metal or glass surfaces is frozen, a firm joint is obtained. However, ice cannot be considered an adhesive because it occurs only at low temperatures and therefore is not applicable in engineering practice.

To select an adhesive for a particular application, factors to be known and considered are: the materials to be bonded, the bonding methods (surface preparation, adhesive application, assembly, conditions of curing), the design of the joint, and the properties (such as withstanding environmental temperatures) required of the cured joint. For example, if very large components are bonded, room temperature curing adhesives must be employed because with heat-curing, ovens, presses, or autoclaves are needed' these are limited in size. Since there are so many factors involved in adhesive selection, a compromise may often be necessary.

Testing

The three basic types of adhesive joint testing are tensile, shear, and peel.



A typical adhesive should possess a definite combination of physical and mechanical properties which make it capable of holding different bodies together without altering their structure.

The basic requirements for an adhesive are:

1. At some stage the bond formation is fluid.
2. While fluid, it should wet the surfaces of the adherends completely.
3. It should set to a strong solid or viscous gel.

To meet the bonding application requirements, which are increasing in number and variety, a vast range of adhesives has been formulated. Cold-setting systems (curing at room temperature) as well as hot-setting adhesives (those requiring heat for curing) are available. This range includes liquid products varying in viscosity from thin fluids to stiff pastes, solid adhesives in the form of powders, pellets or rods, and adhesive films. There are no universal adhesives, but the most commonly used adhesives are the epoxies and silicones. Detailed advise about the effectiveness and behavior of adhesives should be sought from the formulators.

Soldering

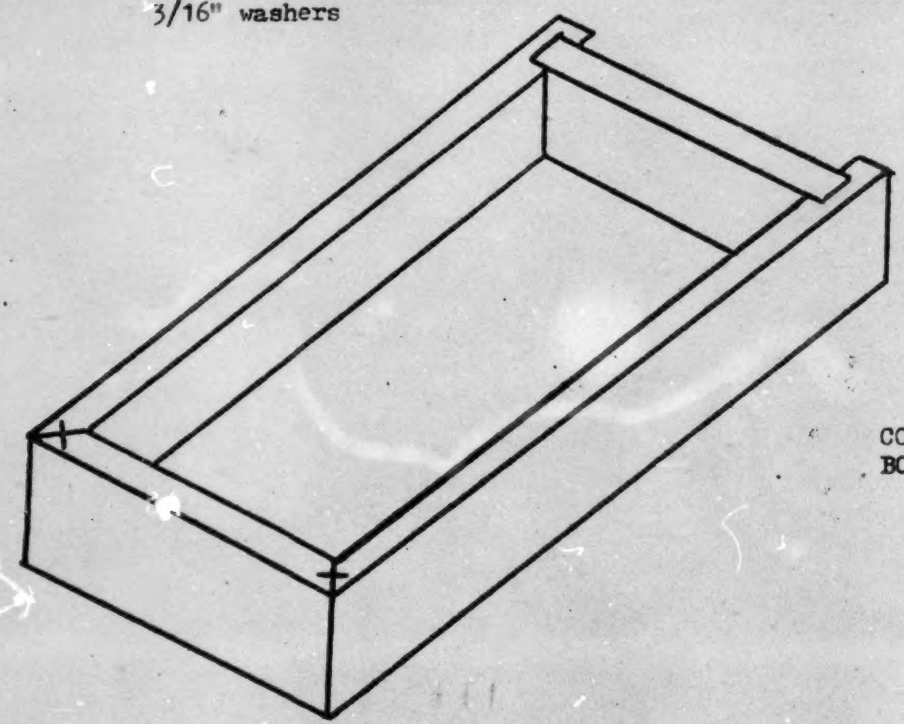
Soldering is a method of sealing and joining metals with a fusible alloy that melts without melting the material being joined. Hard soldering (silver, copper, and zinc alloys) melt at red hot temperatures, while soft solders (tin and lead alloys) melt at temperatures less than 400°F.

MECHANICAL FASTENERS FOR METALS

Non-Threaded	Threaded	Miscellaneous
Rivets	Stove bolt	Retainer rings
Tube		
Solid	Machine screw	Clips
Split		
	Machine bolt	Keys
Pins		Square
Dowel	Carriage bolt	Half moon
Taper		Gib
Cotter	Stud	
Shear		
	Set screws	
	Cup screws	
	Round	
	Socket	
	Fillister	
	Hex	
	Flat	

FASTENING WOOD MATERIALS: COVERED WAGON

Materials needed: White pine
Sides and front 1/2" x 1 5/16" x 24"
Tailgate 1/2" x 1 3/16" x 2 15/16"
Front axle support 3/8" x 3/4" x 3 3/4"
Rear axle support 9/16" x 3/4" x 3 3/4"
Tongue support 5/16" x 1 1/4" x 2"
Seat 1/4" x 1/4" x 2 1/4"
1/4" x 1/2" x 2 1/4"
1/2" x 1" x 2 1/4"
Bottom 1/8" x 3 1/16" x 6 7/8" masonite
Axles and tongue 1/4" dowel
Cover 1/28" veneer
8 1/4" x 8 1/4"
9 1/2" L x 8 1/2" W
Round toothpicks
Glue - shurwood veneer cement
wood veneer specialties
Elliott Bay Lomberto
Seattle, Washington 98104
1/2" x #20 brads
1/2" x #20 wire nails
1" clamp nails
5/8" x #6 R.H. screws
1/2" x #4 F.H. screws
3/16" washers



COVERED WAGON BODY

Procedure

1. Cut 1/8" x 5/16" rabbet in sides on the jointer, to receive the bottom. (Fig. A)

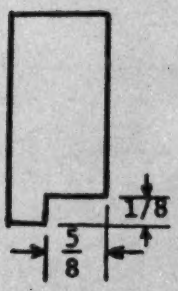


Fig. A

2. Cut a 1/2" dado in the sides on both ends, and cut the opposite end of each piece on a 45° miter. (Fig. B)

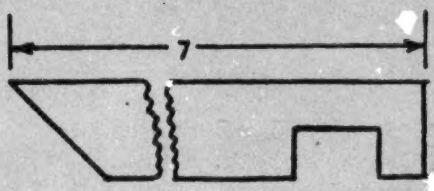


Fig. B

3. Cut the front end to length as shown. (Fig. C)

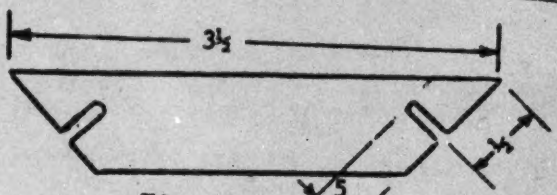


Fig. C

4. Make the cut for the clamp nails, using a 22 gauge saw blade in the miter on both sides and front. Use the table saw fence as a stop, tilting the blade to 45°. (Fig. C)

5. Apply glue to the miters and install the clamp nails.

6. Install the hardboard bottom with 1/2" wire nails.

7. Set the 22 gauge saw blade perpendicular to the top of the table saw projecting a minimum of 3/16" above the table in preparation for cutting slits into wagon body which receive the laminated top.

8. The slit should be cut into the bldy starting 7/8" from the front and continuing until 1 3/16" from the back. Stop blocks may be clamped to the fence if desired.

9. Cut a piece 3 3/4" long off the 9/16" x 3/4" material for the front axle support.

10. Using the router jig and the router (with a 1/4" core box bit) cut the groove 1/8" deep in the axle supports for the axles to fit. (Fig. D)

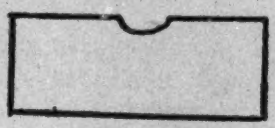


Fig. D

11. Cut two axles 4 7/8" long by using a V-block jig and cut the wagon tongue 3 3/4" long.

12. Band saw the tongue support 5/16" x 1 1/4" x 2" with a 1/4" x 1/2" slot. (Fig. E)

13. Using a drill press vice, drill a 5/64" centered hole in the edge, 5/16" from the front edge. Also drill a 9/64" centered hole on the face through the piece 7/16" from the back edge. (Fig. E)

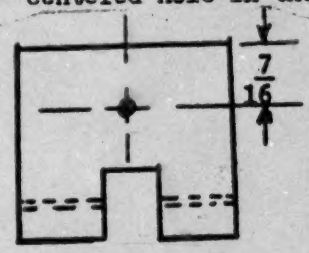


Fig. E

14. Secure the tongue support in the center of the front axle support, using two 1/2" brads and glue. (Fig. F)

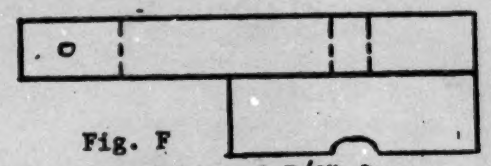


Fig. F

15. Drill two 7/64" holes in the bottom 1 3/16" from the back and 7/8" from each side. Countersink the top of the holes, inside the wagon, to receive the 1/2" x #4 F.H. screw.

16. Drill one 9/64" hole in the front of the bottom one inch from the front and centered between the sides.

17. Make the rear axle support 9/16" x 3/4" x 3 3/4" and rout with a 1/4" core box bit.

18. Center the rear axle support on the bottom 3/4" from the back and mark the axle support for the pilot holes through the holes drilled in step. 15. Drill a 1/16" hole 5/16" deep.

19. Apply wax to the screw threads and fasten the rear axle support to the bottom.

20. With a 5/8" x #8 R.H. screw, fasten the front axle support to the bottom, placing a 3/16" washer under the head of the screw and between the bottom and tongue support to reduce friction.

21. Center and glue the axle to the axle supports with the holes in the axle parallel to the wagon bottom.

22. Cut a piece 2 15/16" from the 1/2" x 1 3/16" stock for the tailgate.

23. Cut two pieces 2 1/4" long from the 1/4" x 1" stock and one piece each from the 1/4" x 1/4" and 1/4" x 1/2" stock to construct the seat as shown in Fig. G.

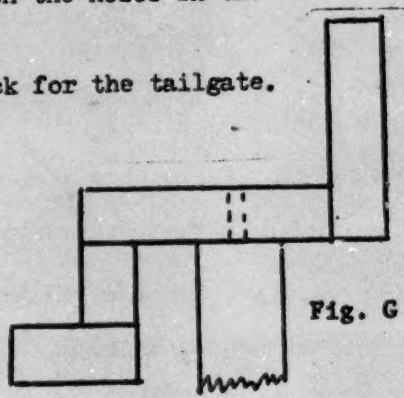


Fig. G

24. Drill two 7/64" shank holes through the seat 3/8" from the inside of the back and 1/2" from each edge. (Fig. G) Counterwink the top of the seat for a #4 screw.

25. Center the seat on the front rail lengthways and fasten the seat to the rail with 1/2" x #4 screws. Use a 1/16" bit for the pilot hole.

26. Cut the wheels from 1/4" hardboard with circle cutters.

27. Cut four pieces of the found toothpick 1/2" long to go in the ends of the axle to hold the wheels on. Cut one piece 1 3/8" and one 1" long for the tongue. It may be necessary to slightly sand the toothpicks to fit the holes.

28. Place the metal template for the wagon cover on the 8 1/4" x 8 1/4" veneer, so the grain of the veneer will run lengthways on the wagon, and transfer the pattern to the veneer with a soft pencil. Cut the cover out with a pair of scissors. Two layers are required.

29. Apply cement to both pieces of veneer except for a 1" strip on the [illegible] of the large piece. Let the glue dry and clamp one piece in the jig by inserting both ends behind the clamping cleats. (Fig. H)

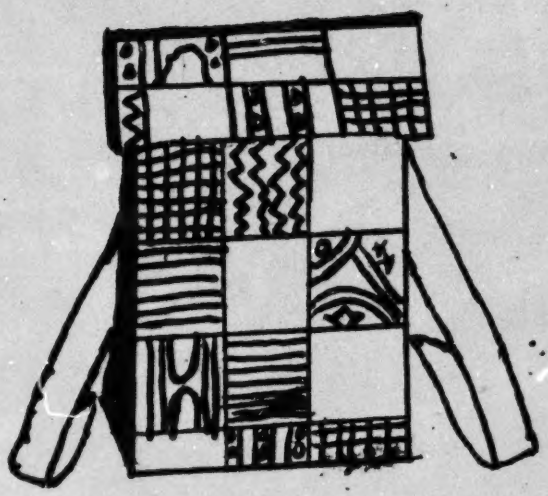
30. Center the outer piece of veneer over the veneer in the jig, with grain running lengthways and working from the center toward the edge, press it down firmly. Use a wallpaper edge roller to apply pressure to the pieces.

Note: It may be necessary to steam the veneer after the contact glue has dried to make the veneer pliable before placing in the jig.

31. Trim the veneer on the bottom piece to the pattern of the outer piece.

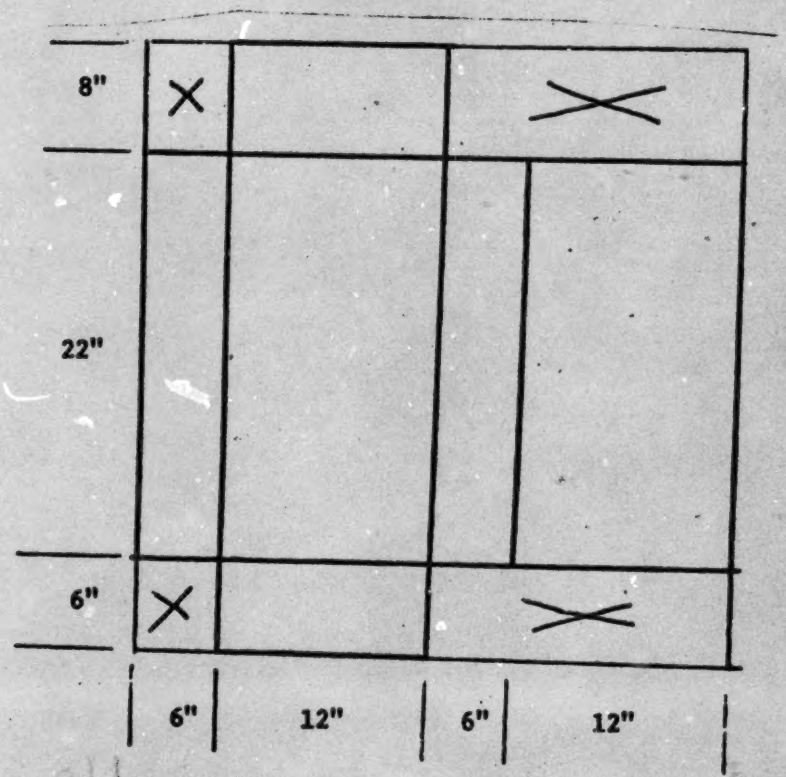
32. Clean and sand all pieces and finish with linseed oil.

CLOTH BACK PACK



1. Select colorful denim fabric - a 36" x 36" piece is required.
2. Layout pattern with a hardboard template by rubbing chalk over the perforated areas.
3. Use scissors to cut away X portions.

4. Sew pattern by hand or machine.
5. Attach nylon webbing straps with rivets.
6. Attach any pockets, buttons, snaps, or patches to meet the individual's needs.



SOLDERING ELECTRICAL COMPONENTS TO PRINTED CIRCUIT

Materials needed:
- 3 - 1 mfd 1000 capacitor
- 3 - 47,000 ohm 1/2 watt resistor
- 3 - Neon bulbs
- 1 - Diode
- 1 - 8' lamp cord
- 1 - Electrical plug
- 1 - Spool of 60 - 40 rosin core solder

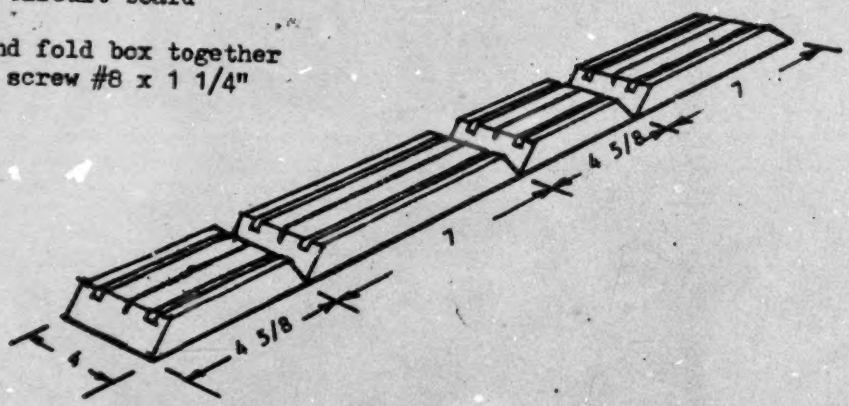
Tools needed :
- Fine abrasive paper
- 25 - 45 watt soldering irons
- Diagonal cutter
- Hand drill

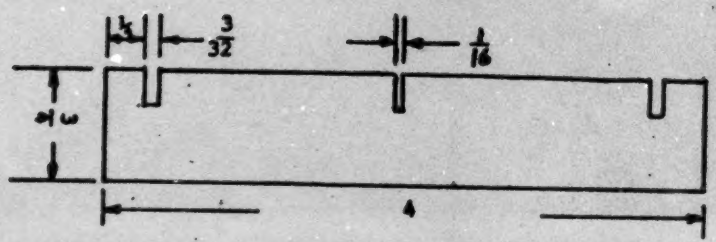
OPTICAL LAMP HOUSING

Materials needed:
1 pc. 24 x 4 x 3/4 white pine
1 pc. vinyl contact paper
12" x 24"
4 #8 F.H. wood screws, 5/8 inch
1 #8 F.H. wood screw, 1 1/4 inch
Polyvinyl glue
1 pc. clear glazing 3/32" x 3 1/2" x 6"
1 pc. synthetic stained glass 3/32" x 3 1/2" x 6"
4 rubber or plastic feet

Procedure

1. Cut core stock to length
2. Cut grooves in core stock
3. Seal core stock with sanding sealer. Sand lightly when dry.
4. Cover core stock with contact paper.
5. Lay out and mark joint cuts
6. Drill holes for cord
7. Cut joints
8. Install printed circuit board
9. Install plug
10. Install glass and fold box together
11. Install locking screw #8 x 1 1/4"
12. Install feet





UNIT VI- FINISHING MATERIALS

COURSE: MATERIALS AND PROCESSES

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
Unit VI - Finishing Materials 121	The student will be able to discuss the following things about finishing: (1) Finishing by forming - obtaining a desired surface texture through pressure (a) Embossing (b) Molding (c) Knurling (2) Finishing by separating - obtaining a desired surface texture by removing material (a) Machining (b) Sanding and grinding (c) Buffing and polishing (3) Finishing by combining - adding materials, generally called finishes, to other materials is a finishing process required on materials not having the desired color or inherent lasting qualities. Mild steel must be coated to prevent corrosion and when a color other than gray is desired. (a) Types of coating materials (b) Characteristics of coating materials (c) Systems for applying coatings (4) Finishing systems unique to specific materials and products (a) Concrete and plaster (b) Paper (c) Timber woods (d) Cabinet woods (e) Textiles (f) Metal anodizing (g) Vacuum metallizing	Discussion-demonstration. Student activities are as follows: (1) The student will finish metals by forming, separating, and combining processes. (2) The student will finish woods materials by separating and combining processes. (3) The student will finish ceramics by combining processes. (4) A "Finishing Systems for Metals" display plaque will be produced by each student. (5) Three wooden picture frames will be finished by each student. (6) The entire set of chessmen will be finished by each student. Readings: "The Purpose and Procedure for Finishing Metals" "Sandpaper Abrasives" "Coatings for Cabinet Woods" Supplies: Completed products for display purposes 1. "Finishing System for Metals" display plaque 2. Finished picture frames 3. Finished chessmen See Appendix V for reading and activity lessons on finishing materials. *This unit will take several days for completion.	See Appendix V-p. 109-125

APPENDIX V

FINISHING MATERIALS

FINISHING SYSTEMS FOR METALS

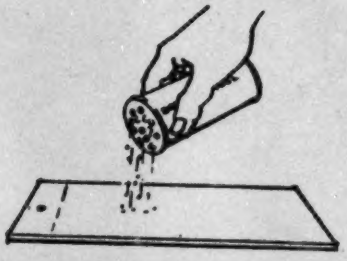
COMBINING MATERIALS

Note: Clean all metals before you add finish materials to them - Sand lightly with fine sandpaper and wipe clean with alcohol

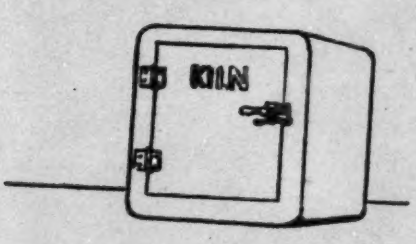
A. Copper enameling

20-26 gauge x 1" x 3" copper

1. Coat with adhesive (gum solution)



2. Coat with dry enamel



3. Fire 1300° - 10 minutes

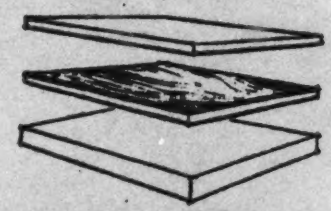
B. Lamination

.020" - .060" x 1" x 3" aluminum

vinyl contact paper 1" x 2"

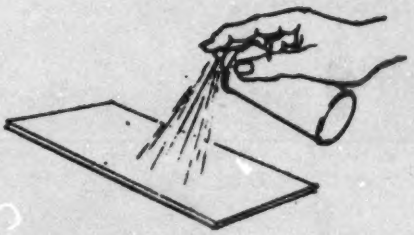
1. Apply vinyl to aluminum

2. Apply pressure to remove air pockets

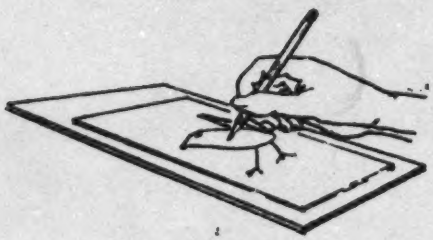


3. Remove part

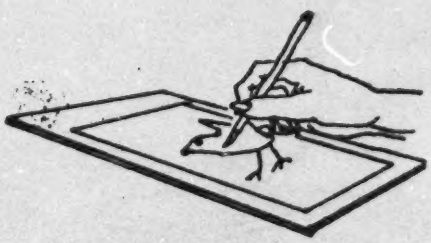
C. Painting



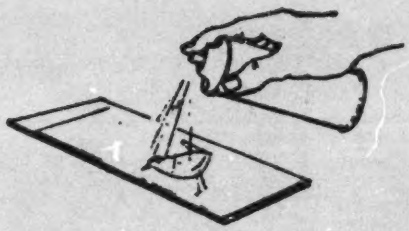
1. Spray with primer



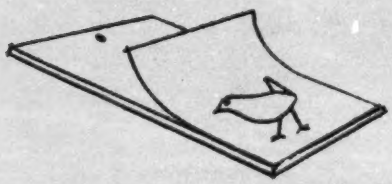
2. Trace design



3. Cut stencil from contact vinyl with sharp knife



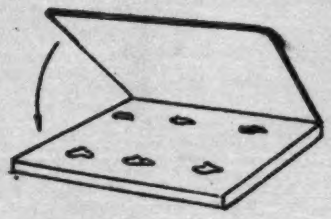
4. Spray stencil figure with contrasting paint



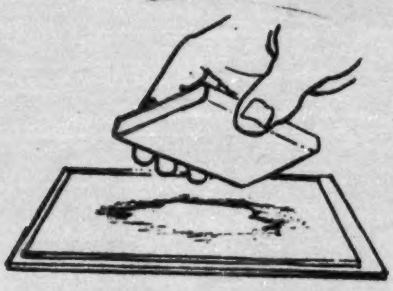
5. Remove stencil from part

SEPARATING MATERIALS

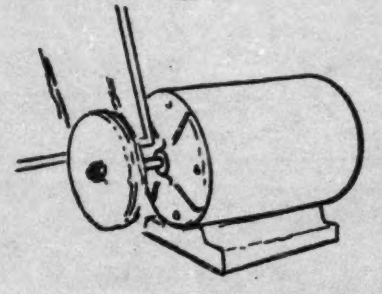
A. Polishing and buffing
20-26 gauge x 1" x 2" brass



1. Glue brass to 4" square of 1/8" masonite with fast setting epoxy

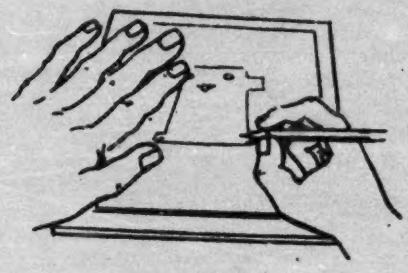


2. Wet sand surface to be polished with 600 grit sandpaper

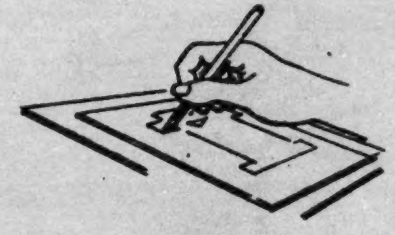


3. Buff on cotton buffing wheel with abrasive compound to desired luster

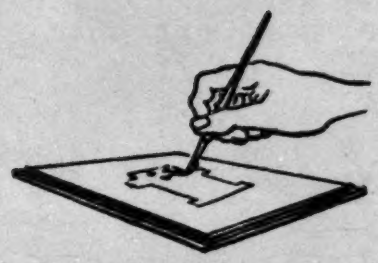
B. Etching
.020" - .060" x 1" x 2"
bright or anodized aluminum



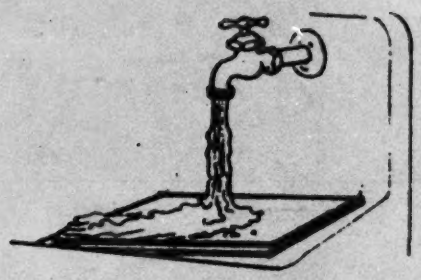
1. Trace design



2. Cut out with sharp knife



3. Cover design with resist



5. Flush off acid with running water over sink

4. Submerge in acid (HCl) for 10 minutes

6. Wipe off the resist

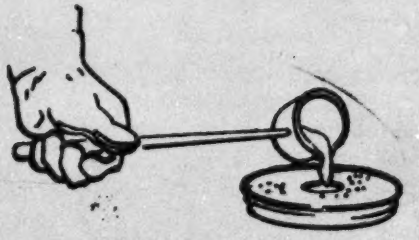
FORMING MATERIALS

A. Mold surface texture

pattern
(large coin)

jar lid
3" - 4"
diameter

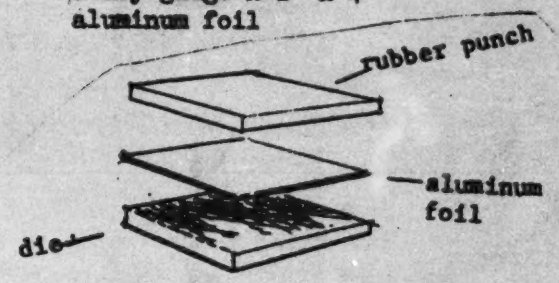
1. Push pattern into sand and remove



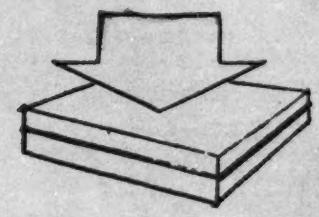
2. Pour hot lead into mold cavity

B. Embossed surface

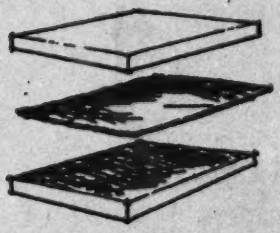
heavy gauge x 2" x 4"
aluminum foil



1. Place aluminum foil between die and rubber punch



2. Closed under pressure of vise or hydraulic press



finished part

3. Open and remove part

THE PURPOSE AND PROCEDURE FOR FINISHING METALS

METAL FINISHING

A finish is applied to most metals by many different methods and for a variety of reasons. Finishes are used for one or more of the following purposes:

1. To improve the appearance of the product such as the attractive chrome plating on appliances.

2. To prevent corrosion like the rush inhibitors that are applied to the interior and exterior of an automobile body to keep it from rusting.

3. To cover a less expensive metal with a thin coating or more expensive one such as table silverware, made of nickel, silver, or brass; then plated with pure silver.

4. To improve the wearing quality of surfaces, such as the super-fine grinding done to the moving parts of a jet engine.

METAL CLEANING

Before a metal surface can be painted, it must first be cleaned. Mechanical and chemical systems are used to clean metals.

Solvents and acids are used to degrease (remove oil and film from the metal). The parts can be dipped into the solvent or acid solution or they may be brushed or scrubbed with the solution. Mechanical cleaning involves abrading or sanding the metal surfaces with wet and dry abrasives. This helps to remove corrosion and scale from the metal surfaces.

FINISHING PROCESSES

Metal finishing processes are used for many purposes, the most common of which are to improve metal appearance and to protect the metal from rust and corrosion. Four finishing processes are very commonly used in industry.

Coating with paint and similar materials: Probably the best known finishing process is the coating of metal with paint, enamel, varnish, or lacquer. In industry most of these finishes are applied by spraying, often with automatic spray guns. Special lamps or ovens are usually used to dry these finishes rapidly.

Coating by dipping in other metals: Another common type of metal finishing is hot dipping. "Tin-plate", for example, is sheet steel which is cleaned and then dipped in molten tin, which forms a thin layer on the surface of the steel.

Electroplating: Electroplating is a process of coating metal with another metal by the action of chemicals and electricity.

Enameling with porcelain: Porcelain enameling is a process used for finishing things like bathtubs, refrigerators, and kitchen stoves. Special porcelain enamels are spread evenly on the metal and then fired (or fused) in kilns to form a hard, glass-like finish.

PRIMERS

In order to secure the proper cohesion of most paints and enamels to metal surfaces, a primer has to be applied first. There are many types. Some are made especially for application to steel, such as automobile bodies. This is lead primer. Zinc and lead chromate primers can be used to steel, zinc, and aluminum for satisfactory results - for instance, on aluminum siding before enamel is baked on.

WHEN THE FINISH SHOULD BE APPLIED

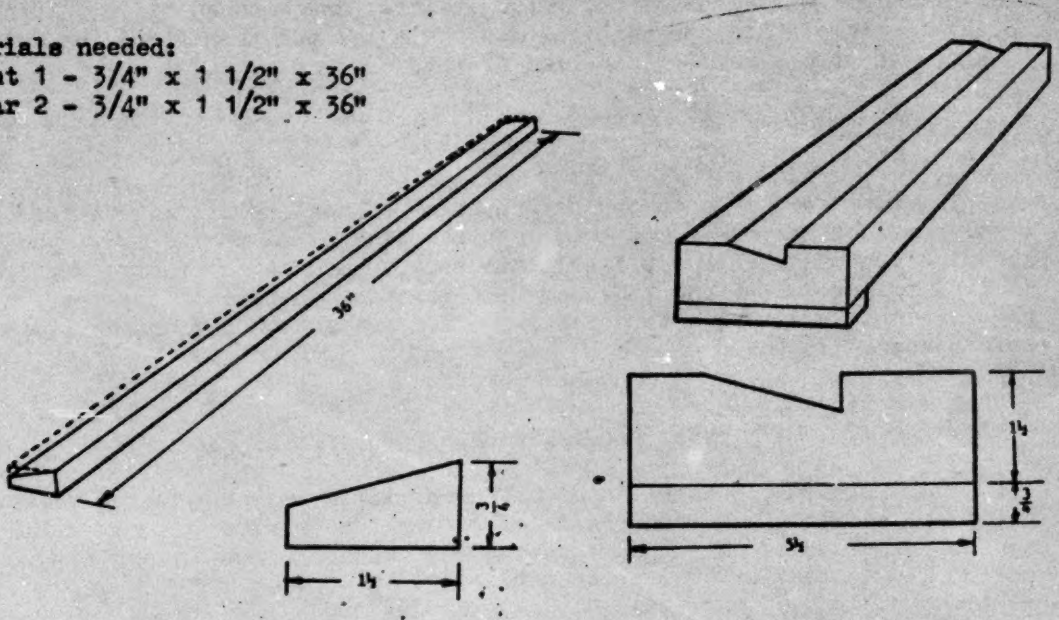
The finish may be applied at different times in the assembly process or after all assembly has been completed. Sometimes a part is painted before assembly because it can't be reached after assembly. At other times, certain color combinations or designs require painting before assembly.

FINISHING PICTURE FRAMES

Each student will construct and apply three types of finishes to three picture frames. The three types of finishes are: (1) fine furniture finish (lacquer), (2) antique finish, and (3) textured finish.

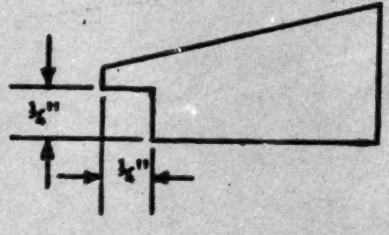
Each student will cut one complete frame from walnut and two complete frames from poplar.

Materials needed:
Walnut 1 - 3/4" x 1 1/2" x 36"
Poplar 2 - 3/4" x 1 1/2" x 36"



Procedure

1. Shape frame face using surfacer and jig to proper cross-section size and shape.



2. Cut rabbet on the table saw using the rip fence with wooden facing.

3. Rough cut picture frame stock to length, cutting two 8" pieces and two 10" pieces for each frame, and cut picture frame to correct length using cutting jig. Be careful to cut two 7 1/2" lengths and two 9 1/2" lengths for each picture frame being built.
   a. Cut one end of each piece on right side.
   b. Cut the other end on each piece on the left side using appropriate stops.

4. Sand surfaces of each board using 100 grit abrasive paper, then 150 grit abrasive paper. Be careful not to round edges in the joint areas.

Assembly of components by combining with adhesives and mechanical fasteners

1. Trail clamp frames in the miter clamp to check fit on the corners. Remove from clamp and apply glue to each joint surface. Allow glue to absorb into the end grain and apply a second coat of glue. Reclamp the frames into the miter clamp; pilot drill and nail each corner with finish nails. Set the nail head with a nail set.

2. Remove from miter clamping frame jig.

3. After the glue has dried scrape off excess glue and finish sanding the entire picture frame very thoroughly. If the corners of the picture frame are uneven, scrape first with a cabinet scraper blade for fast removal of unwanted stock, then sand. First use 100 grit, then 150 grit paper. Check walnut frame for mill marks, dents, flaws, uneven jointing at corner. The poplar picture frames need not be sanded with the same high quality as the walnut frame because of the type of finish they will receive.

4. Refer to the section on application of finishes and apply one each of the following finishes:
   a. Fine furniture finish
   b. Antique finish
   c. Textured finish

DANISH OIL FINISH

1. Using a 1" brush or rag, apply a liberal coat of Danish oil to the surface. Do not brush the finish too thin. It must penetrate the wood.

2. Let the finish penetrate 25 minutes.

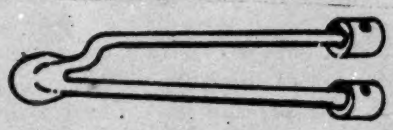
3. Apply a second coat of finish.

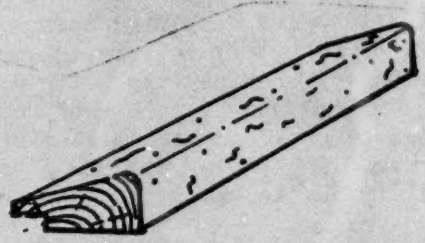
4. Let the second coat penetrate for about 10 minutes and wipe off any excess with a rag.

5. For a superior finish, let the project dry overnight. With a piece of steel wool or 600 wet-or-dry sandpaper dipped in Danish oil, rub the surface with light pressure to obtain a soft luster. Wipe the surface clean with a rag.

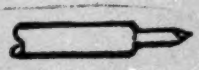
IMITATION WORMY WOOD FINISH

1. Using the flat, broad tip of a soldering gun, turn the gun 90 degrees and use the edge of the tip to freehand imitation worm lines.





2. Use a small soldering tip that has been filed to a point and burn small worm holes.



3. Grasp both ends of a short piece of sash chain (approximately 12") in one hand and strike the surface of the frame numerous times to give the frame a distressed appearance.

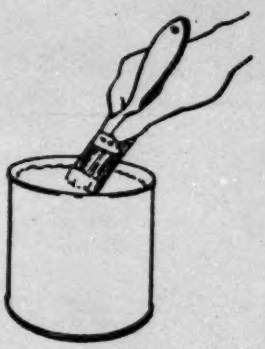
4. Apply the oil or fine furniture finish to the frame. However, if the fine furniture finish is used, do not rub out or polish the finish. Use 2/0 steel wool in place of the abrasive compound which will give a satin smooth semi-dull finish.

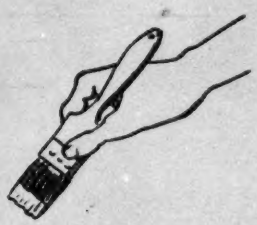
ANTIQUE FINISH

1. Stir the base paint thoroughly until it is of uniform consistency.

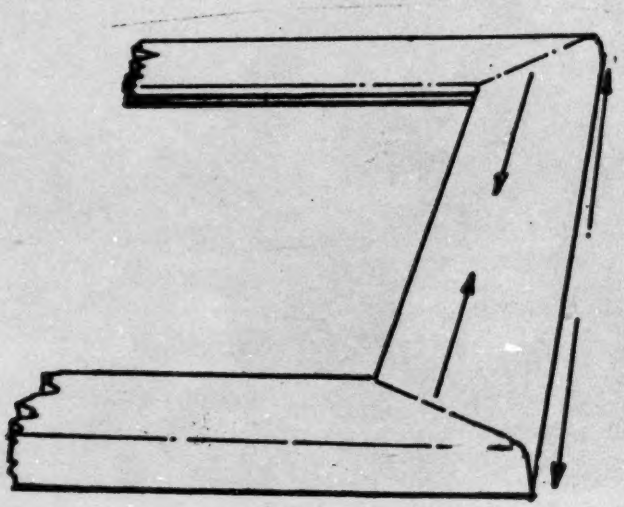
2. Select a good quality 1" varnish brush.

3. Dip the brush into the base paint about 1/3 to 1/2 the length of the bristles and pull it lightly over the edge of the can.





4. Hold the brush as indicated. Apply the base paint with the grain, lengthwise, until one side is covered. Eliminate the brush marks and level the paint by starting in the corners. With the tip of the bristles, stroke lightly toward the middle of the board, lifting the brush from the work as you pass the midpoint. On the outside edge it will be necessary to brush the paint from the middle out over the end to prevent wiping the paint off the brush onto the corners, causing a run. For the best results do the edges first and the face last.



5. Repeat step 4 on the remaining sides.

6. Let the paint dry for 24 hours and sand lightly with 220 grit sandpaper.

7. Apply the second coat of base paint.

8. After 24 hours sand very lightly with 220 grit sandpaper.

9. Stir the glaze thoroughly.

10. Place a small amount of glaze material on a piece of aluminum foil.

11. Remove the 1" varnish brush used for the base paint from the container and wipe as much of the thinner from the brush as possible.

12. Dip the tips of the bristles into the glaze on the foil and lightly cover one side of the frame.

13. Wipe the brush as dry as possible, using the same procedure as was used to level the base paint. Brush the glaze with the dry brush. Continue wiping the bristles on a rag, brushing out the glaze until the desired appearance is achieved. Brush in straight lines and always brush with the grain.

14. Upon completion of the glaze coat, suspend the brush in the can of thinner.

15. Use a brush with stiff bristles if a spatter finish is desired. A toothbrush works well. Dip the tip of the bristles in the glaze and with your fingers bend the bristles back and flip the spray toward the frame. Practice on a piece of paper first.

    Note: Spatter is a "chance" method. Therefore, it is best to let the glaze dry overnight. If your first try isn't satisfactory, you can wipe it off and try again.

FINE FURNITURE FINISH

1. Thoroughly stir the desired stain until it is of uniform consistency. Note: It is not necessary to stain walnut (omit steps 2 and 3) unless you have some sapwood you want to stain.

2. Using a stain brush, apply a coat of stain to the wood. Do not brush it as you would varnish; just coat the wood and let it stand for a few minutes.

3. Wipe all surplus stain from the wood with a soft rag. On the final clean up, wipe with the grain, lengthwise, to eliminate streaks. Let is dry for 24 hours.

4. If the wood has open pores, such as walnut or mahogany, paste filler must be applied to fill the pores.
   a. Select a filler that matches the wood.
   b. Stir the filler until all the material in the bottom of the can is thoroughly mixed with the vehicle (liquid) to form a creamy consistency.
   c. Using a stain brush, apply a coat of filler to the entire picture frame.
   d. Using a circular motion, rub the filler into the pores with the tips of your fingers. It is not necessary to apply a great deal of pressure.
   e. Let the filler set for a few minutes until it loses its wet look and turns dull.
   f. Use a coarse rag and wipe across the grain from side to side, to remove the surplus filler.
   g. Finish by wiping lightly with the grain. Use a clean, soft rag. This removes the streaks caused by wiping across the grain. Let it dry for 24 hours.

5. Spray the frame with a coat of sealer. Aim the gun straight and keep it approximately 8" from the object being sprayed. Keep the gun parallel to the surface, starting it to the outside of the surface and moving to the right. As the center of the gun becomes even with the frame pull the trigger as far back as it will go and release as necessary to spray each side twice, pointing the center of the nozzle at the two edges indicated.

6. Let the sealer dry 30 minutes and sand lightly with 400 wet-or-dry sandpaper.

7. Spray the frame with three coats of lacquer. Allow 20 minutes between coats.

8. Let the finish dry 24 hours and sand the surface with 400 wet-or-dry and water. Dip the paper in water and keep it wet to obtain a dull satin smooth finish. Wipe the surface clean.

9. Using a felt pad or a pad made with a soft rag, apply a small amount of prepared rubbing compound to the pad and rub with the grain until a soft gloss is obtained. Be careful not to rub through on the corners. Wipe the surface with the grain, using a soft rag and removing all the compound.

10. To obtain a high gloss, moisten a small pad made with a soft rag with water and apply French Glow to the rag. Rub briskly with the grain. Wipe the surplus French Glow off the frame and buff it with a soft rag to get the maximum of gloss.

TEXTURED FINISH

1. Make a sealer by mixing 1 teaspoon of acrylic polymer modeling paste in approximately 1 tablespoon of water.

2. Use a 1" nylon brush and apply this mixture to your picture frame to seal the wood. Let it dry for about 30 minutes. Wash the brush in water.

3. Spread a layer of the acrylic paste on the large face of one side of the frame with a putty knife. Dip the tip of the nylon brush in water and distribute the paste evenly on all sides of the frame. Add more paste if it is needed and dip the tip of the brush in water as the paste becomes too heavy to spread.

4. Wet the sponge in water and squeeze it to remove all the water. Place the sponge lightly against the paste and lift it straight out 90 degrees to the surface to texture the surface.

5. Repeat steps 3 and 4 on the remaining three sides. It will be necessary to rinse the sponge occasionally in water.

6. Clean up all tools with water.

7. Let the paste dry overnight.

8. Shake the aerosol can of pale gold vigorously until you can hear the steel ball hitting inside the can. Continue shaking the can up and down and in a circular motion to mix the paint settled on the bottom of the can.

9. Point the opening in the nozzle toward the textured frame, holding 10" to 12" from the surface. Proceed as if you were using the spray gun.

10. After the spraying is completed, hold the can upside down and spray a short burst until the paint no longer comes our of the nozzle. Clean the face of the nozzle with a rag moistened with turpentine.

SANDPAPER ABRASIVES

Proper sanding is one of the most important finishing operations. The term "sandpaper" probably got its name many years ago when sand was glued to paper and used in that way. Today there are four main different mineral grains of various degrees of hardness that are used. Two are natural, being mined or quarried, and two are synthetically produced in electric furnaces. The natural minerals are:

Flint - Flint is generally off-white in color. It is commonly sold in hardware stores, but is not normally used in industry, because of its softness.
Garnet - Garnet paper is widely used industrially and is especially suited for sanding operations on wood and wood finishes. The color of garnet is orange-red.

The synthetic minerals are:

Aluminum oxide - reddish-brown in color; made in electric furnaces by fusing the mineral bauxite at very high temperatures. Its toughness and enduring sharpness make it a fine abrasive, for both wood and metal.
Silicon carbide - also an electric furnace product; produced by high temperature fusing of silica, sand, and coke. Silicon carbide, approaching the hardness of diamond, is a very sharp abrasive and may be used on lacquers, plastics, metals, stone, and ceramic materials.

Most abrasive papers come in two types of coating: closed and open coat. Closed coat papers have tightly packed abrasive grains that cover their entire surface. Open coating, having only 50 to 70 percent of the surface covered, tends not to clog up and is used mainly on machine sanding.

Abrasives are available in different backing such as paper, cloth, cloth-paper combination, fiber, or fiber-cloth combination. Paper backing comes in four weights, which are designated as A, C, D, and E, with grade A being the lightweight.

Abrasives are available in coarse, medium, and fine. The grit is classified as 3 (very coarse) to 10/0 (super fine). Also from number 24, (coarse) to 600 (very fine). Abrasive paper is available in standard size 8 1/2" x 11". They also come in disks, drums, and belts for use with the various types of power sanding tools.

COATINGS FOR CABINET WOODS

SANDING SEALER

Sanding sealer, while filling slight imperfections, is a product that will seal the wood in such a manner as to prevent penetration of subsequent coats. This material is formulated with good sanding qualities and by applying several coats, while sanding between each one, a very smooth seal is possible prior to final coating with lacquer.

LACQUERS

Because of its drying speed and outstanding durability, lacquer is an ideal finish for furniture, fixtures, cabinets, metal products, etc. Lacquers are divided into two classes: high solids and medium solids. The high solids lacquers are made from low viscosity nitrocellulose. They leave a thicker film than the medium solids lacquers. Lacquer thinners are often required to lower the viscosity for spraying purposes.

OIL FINISHES

An oil finish is primarily used to penetrate the wood for preservation purposes and to enhance the appearance of wood grain. Linseed and other oils soak into the wood after having been applied with a pad of linen or other lint-free cloth. After several minutes of soaking, the excess oil may be removed with a soft cloth. The oil which has penetrated the surface will dry and harden. A smooth, satin, uniform surface is obtained and oil may be used to finish fine furniture, TV cabinets, gun stocks, doors, and floors. An oil finish, while beautiful, is not regarded as a durable finish.

SHELLAC FINISHES

Shellac finish is used frequently because it is easy to apply, quick-drying, and dries very hard. It can be used as a sealer to prevent knots, sappy runs, and stains from bleeding into finish coats. Shellac stains easily, has poor water resistance, and has no resistance to alcohol.

ANTIQUE FINISHES

Antique finishing is a finishing system which usually consists of an opaque base coat, glaze coat, and finish coat. The base coat is the foundation for most antique finishes. One coat is usually sufficient on previously finished surfaces, but two coats should be used on new or unfinished woods. The second coat is the glaze which the antique "pattern" effect is created. This is accomplished by applying and then partially removing the glaze. The pattern may be created with a wad of cheesecloth, a dry brush, paint brush, or a dry whisk broom. After the proper pattern has been created and allowed to dry a clear finish coat is applied. With a little experimenting, lovely patterns can be created.

UNIT VII - DEVELOPMENT OF PRODUCTS

COURSE: MATERIALS AND PROCESSES

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
Unit VII - Development of Products	The student will be able to discuss how products are designed and built.	Discussion-demonstration. The students will be shown the "Engineering Format (Design Procedure)" and will develop products from the ideas given by the instructor or some of his own. Students will use the "Design Analysis Chart" to insure that all design phases are included in product development. Students will proceed according to the design procedure, marking off each phase as it is completed. The instructor should go over each phase with the students. Students will present the following items to the instructor: (1) Completed "Design Analysis Chart" (2) Preliminary sketches and data (3) Refined sketches and data (4) Models (5) Final design drawings and data (6) Completed products Instructor's activities are as follows: (1) Instructor should hand out and discuss the thirteen phases in the engineering procedure that are followed in designing a product. (2) Instructor should hand out and discuss the design analysis chart. (3) Hand out laboratory activity sheet. Discuss the project with students. (This is Phase I of the Engineering Format).	See Appendix IV-p. 128-139

TOPIC OUTLINE	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES	RESOURCES
		(4) Divide students into groups of five for role playing activities. These groups should contain representatives of management, engineers, and clientele Reading: "Engineering Format (Design Procedure)" "Designing a Product" Supplies: Paper Pencils Resource library Necessary materials and tools to build mock-ups, prototypes, and products See Appendix VI for readings and student activity lessons of "Development of Products".	

APPENDIX VI

DEVELOPMENT OF PRODUCTS

TYPICAL PRODUCT IDEA INTRODUCTION

MARBLE AND CULTURED MARBLE

As you develop the cultured marble product you will become acquainted with the procedures of how marble is quarried, where the main sources are found in the United States, and which state is the leading producer. The use of marble will be explained. The cost of marble will be explained to show why marble is too expensive for widespread use in the building industry. Cultured marble which has been developed by using marble dust, thereby overcoming the high cost, will also be explained.

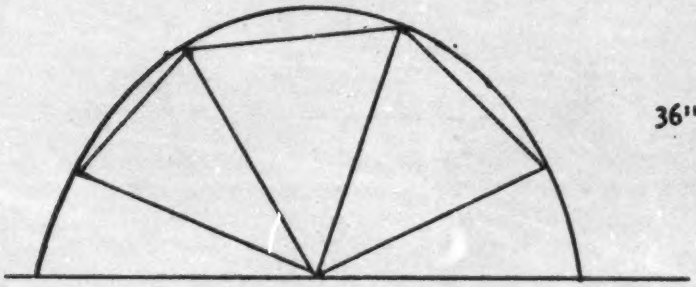
Discuss the following points:

1. Characteristics of marble
2. How marble is processed
3. Typical products made of marble
4. How marble is simulated
5. Types of tools used to mold cultured marble
6. By using the Engineering Format (Design Procedure), you will research and develop a cultured marble product. The product may be a small wall ledge, vanity top, soap dish, a small table top, or an ornamental desk set. (Must be a product which utilized the qualities of marble stone)

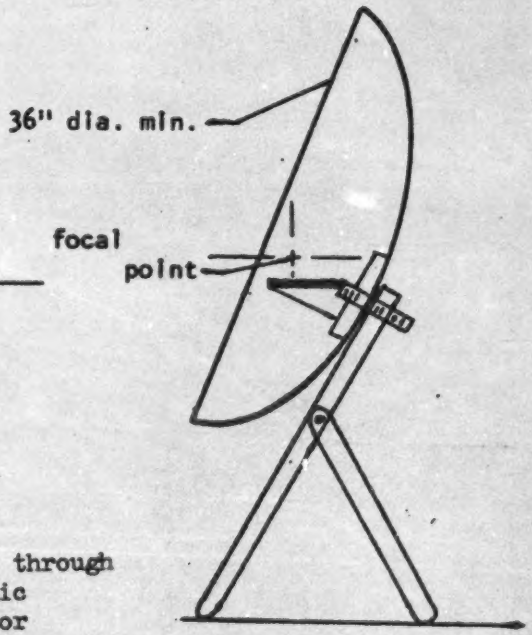
PORTABLE SOLAR STOVE

Design a Portable Solar Stove (using the design procedure given you) suitable for survey parties and campers, for use in relatively sunny climates. It must be lightweight and disassembled to pack into a small box. A parabolic reflector at least three feet in diameter must be used, and its focal point must not be too precise or it will tend to burn a hole in a small container. The reflector must be on an adjustable mounting so that it can be focused on the sun at different times of the day and year, and at different latitudes.

The suggested solution consists of a reflector made of eight properly developed segments of polished sheet metal. These segments lie flat when not in use, and are bent to the proper shape by fasteners holding the segment edges together.



Development of three segments of eight segments reflector - suitable fasteners will pull flat pieces to parabolic curve.



Section through parabolic reflector

DESIGN ANALYSIS CHART

(Instructions)

This chart will help you in the critical analysis of the completeness of your product (solar oven) design. You will need to check all the appropriate selections in each category as they apply to your design. The five main topics are listed at the left with the categories across the top. All necessary comments may be added in the open areas provided. This chart will help you take into consideration all of the necessary elements for the design of your product (or any other product). Use these considerations as you follow the Design Procedure given to you by your teacher.

I	Enclosing and Protecting	Supporting	Converting Energy
What are the basic functions of your product and its component parts?	Covers	Frames	Chemical to heat
	Cases	Structures	Electrical to mechanical
	Compartments		
	Protective films		
	Resistance to wear		
	Resistance to environment		

Transmitting	Assembly	
Movement	Firings	
Power	Fastenings	
Energy		
Force		
Information		

The following four sections of this chart are the four main design characteristics used in the formulation of a product. II How does your product work and what are its functions?	Means	Techniques	Applied Functions
	Mechanical	Mechanical	Application
	Electrical	Electrical	Function
	Electronic	Electro-mechanical	Means
	Thermal	Chemical	
	Optical	Electrochemical	
	Nuclear		
	Chemical		

Supplied Parts	Conditions	Efficiency
Functional	Resources	
Price	Application	
Delivery	Mode of use	
Quality		

III How is your product used?	Information	Types of Operation	Work Study	Service
	Visual		Sequence of operations	
	Touch		Environment	
	Sound		Effort	
	Subsonic vibration			
	Heat			
	Smell and taste			

	Aesthetic	Characteristics	Achievement
IV How does your product look or appear to others?		Shape Design Features Materials and finishes Color and tone Quality	

	Method	General Principles	Design Features
V How will your product be produced?			

DESIGNING A PRODUCT

1. Introductory - Design Categories. The word "design" has many meanings. A digest of various dictionary definitions is: to plan, conceive, invent, and designate so as to transmit the plan to others. Design has many purely artistic connotations. For example, the design of fabrics, clothing, furniture, etc. In engineering, design has come to mean that broad category of invention leading to the production of useful devices.

Design, from the Latin "designare" (to mark out), is the process of developing plans, schemes, directions, and specifications for something new. Thus, it is within context to speak of Hitler's designs for world conquest; the design (conception) of a book, play, or motion picture; or the design of fabric, clothing, furniture, appliances, or other completely physical objects. Design is distinguished from production and craftsmanship: design is the creative original plan, and the production and craftsmanship are a part of the execution of the plan.

Design means creation in the purest sense. Specifically, design does not go beyond creation, and it logically follows that the execution of a design, (that is, the carrying out of the plan by presentation, action, production, manufacture, craftsmanship, and use) are not design at all but are simply and positively the products of the design. Also, when examining a finished product, it is proper to speak of the design of it, and by this term of reference we mean the original plan or scheme and not the product itself.

A design may be presented by means of drawings, models, patterns, specifications, or other similar methods of communication. By whatever means the design is made known, every detail important to consummation must be given. This will include such items as materials and their capabilities, the methods of adapting the materials to their purpose or work, the relationship of parts within the whole, and the effect of the finished product upon those who may see it, use it, or become involved with it.

Design is a word used more or less loosely in all the arts in referring to composition, style, decoration, or any relationship of the parts of a complete entity. In some areas, notably in architecture and in product design, art, and engineering affect each other, so that complete freedom is often somewhat restricted. Usually painters, poets, musicians, and some others can design with great freedom.

Logically, one who designs is called a designer. All designers must be experienced and educationally organized and oriented. In other words, a designer must know a great deal about what he is attempting to design or he will fail miserably. As an example, suppose that a person who has never fished and knows nothing about the sport, attempts to design a fishing reel. Because of his ignorance of such aspects as weight, balance, line capacity, drag characterists, and overall performance, such a person is completely incapable of producing a good design. Nevertheless, most good engineering designers are capable of designing a wide variety of devices because of

their knowledge of materials, processes, production methods, and other related aspects. Designers may be likened to executives in large companies, especially such people as editors and directors. The executive will decide policies and business methods and then transmit his ideas to colleagues who carry out the executive orders. The designer conceives his design and then transmits his plans to others who produce the product. This does not mean, however, that a designer never is involved in production. Especially in the fine arts, a designer may actually produce the product himself.

Design, in a broad sense can be and often is, classified according to its relationship to practicality. Thus abstract design has no relationship whatever to useful or physical objects and is intended only to create a visual interest or impact. Much of so-called "modern" art is abstract design. Aesthetic design is a design applied to some useful object. The design is intended for decorative purposes alone, and has nothing whatever to do with the usefulness of the object. The design is aesthetic only and performs no practical purpose. Other examples of aesthetic design are found in furniture, architecture, motorcars, appliances, floor coverings, and other useful objects where the design per se, has no function but to decorate and create an aesthetic impact. Aesthetic functional design is that category of design where aesthetic and functional aspects are closely allied. An example is a Baldwin theater organ, a fine musical instrument as well as an outstanding aesthetic and traditional design. To see how function affects aesthetics note that the seat must be wide enough at the base to cover the width of the 32 note pedal board. Thus, the aesthetic design must be accommodated to functional requirements. The curved console is not only traditional and aesthetically interesting but also has a function in that the tabs controlling the voices on the two manuals are more convenient to the organist. It is interesting to note here that the Baldwin theater organ contains completely transistorized tone generators and amplifiers and the most modern of speaker systems, and the cabinet proper must be sized and designed for acoustics and to accommodate the fundamental parts of the instrument. Purely functional design is any design where function is completely dominant with aesthetics not considered at all. An example is a 3KVAR, 250-volt single-phase, sixty-cycle capacitor used on electric transmission lines. This piece of equipment is completely functional and aesthetics plays no part in the design. Other examples are machines, such as lathes, boring machines, motors, power tools, conveyors, material-handling equipment, and the great bulk of manufacturing and production equipment.

Even though aesthetic considerations may be present in engineering design, the emphasis in this discussion must necessarily be restricted to good functional engineering design. However, never entertain the thought that pure function always prevails as the governing factor. As an example, in early automotive design the machine proper was designed to cover the machine. Recent automotive design shows that because of body shape, many components have been redesigned and moved from former positions in order to accommodate to body design.

Some of the best examples of design in all aspects are to be found in automotive and commercial aircraft design. Purely aesthetic features are evidenced in colors used; elegance of fabric, plastic, or leather in upholstery; finish and appearance of appointments, body lines, and artistic configuration. Functional-aesthetic features are obvious in such aspects as artful and functional controls, dials, instruments, glass areas, seat comfort, and safety features. Purely functional design is clearly manifested by examination of the power supply and all of its auxiliaries and components.

There are many categories of engineering design, such as machine design and structural design. Paralleling this, the designer working in a particular field is designated by his field or subclassification in it; for example, machine designer, appliance designer, structural designer, automotive parts designer, etc.

Even though the field of design is broad, all designers think and produce in much the same manner. Simply put, the designer draws upon his background of knowledge and experience in producing a new entity. Thus, every designer must have: (1) knowledge in his field, (2) experience, (3) inventive ability, (4) a knowledge of materials and processes, and (5) the ability to represent (draw) so as to transmit his designs to others.

2. Procedure - How a Designer Thinks. First, in approaching a new project, the designer must recognize and thoroughly understand every phase of the problem. This will include all information necessary to state what the device is expected to accomplish and the pertinent data such as speeds, pressures, temperatures, and operating conditions. Also, statements of relative size and appearance are often included.

Second, the search for solutions is started, and here the real ability to create shows itself. In the beginning, conventional solutions will come to mind, and there may be several of them. Then, as the investigation continues, newer, more modern, and previously unheard-of answers may appear. At this stage, the designer should let his imagination really "run rampant". Every unusual physical, chemical, and electrical application, use of material, combination of elements, and their relationships, should be carefully studied. A number of possible solutions will probably emerge. Sensitivity to the problem, the ability and desire to create, coupled with originality and the worker's ability to analyze and synthesize, characterizes this stage of the work. Perseverance and persistence offer the key to success here.

While the solutions are being composed, the designer must make sketches for his own use. To be sure, these may be very "rough" and may lack detailed information, but they will probably include many written notes giving information for later use. This is where real ability and facility in the use of the graphic language plays a very important role. An active mind and fluency at recording the mind's products of originality on paper combine to produce successful solutions.

Third, all of the solutions should be evaluated. This analysis must include feasibility of the design from every standpoint - from every engineering detail to economics and aesthetics. This must be done carefully and honestly because it is principally self-evaluation. Personal idiosyncrasies and preferences should be subservient to a completely "open mind".

Fourth, either decide on the best solution or continue the search for a better solution.

Fifth, obtain approval of the design. The practice here varies with the size of the organization. Company practice prevails.

Sixth, refine and correct the original design and make more complete sketches as a guide before starting a formal design drawing. Some alterations may be a result of the approval conference on the design.

Seventh, make a formal design drawing. This drawing must show all information that will be needed by detailers who will make the individual part drawings, subassemblies, and assemblies.

Eighth, obtain final approval of the design.

All this is not quite as difficult as one might think. The real key lies mostly in the ability to draw, both freehand and with instruments; it is then the creation develops. At this time all the designer's knowledge, experience, and skill are brought to fruition. As he thinks of ways to solve the problem - considering methods, materials, combinations, and arrangement of components - he records his thoughts and develops his design. Because of the creative aspect, designing is personally very interesting and satisfying.

ENGINEERING FORMAT - (DESIGN PROCEDURE)

I. Phase One - The project

A. Discussion with management, engineering, clientele

B. Statements and specifications of the design problem

C. Collection of all pertinent information

II. Phase Two - Formulation

A. Recognition of requirements

B. Definition of requirements

C. Consideration of previous designs

D. Assembly of all original data needed - mathematical, graphical, mechanical, electrical, etc.

III. Phase Three - Concepts

A. Preliminary design sketches

B. Preliminary design data giving materials, methods, construction details, and projected characteristics

IV. Phase Four - Analysis

A. Critical analysis of all design concepts

B. Selection of most promising design or designs

V. Phase Five - Design Conference

A. Discussion of preliminary designs with engineering, management, and clientele

B. Approval of design or designs

VI. Phase Six - Refinement

A. More complete drawings and specifications of selected design or designs

B. More complete data supporting projected design

VII. Phase Seven - Design Conference

A. Discussion of refined design or designs

B. Approval of most promising design

VIII. Phase Eight - Synthesis

A. Projected design supported by mathematical, graphical, and computer-aided and combined systems data

B. Investigation of all physical aspects and proof of the soundness of design

IX. Phase Nine - Models

A. Components

B. Mock-ups

C. Models of critical features

D. Prototype

X. Phase Ten - Testing

A. Proof of operating characteristics of components

B. Proof of soundness of complete entity

XI. Phase Eleven - Conference

A. Final discussion with originating authority

B. Approval of final design

XII. Phase Twelve - Final Preparation

A. Final design drawings

B. Final specifications

XIII. Phase Thirteen - Transmittal

A. Transmittal of final design drawings and specifications to originating authority

RESOURCE MATERIALS

The following list of resource materials is by no means complete or exhaustive. It merely represents a compilation of the best and most available material known and used by the members of the committee.

1. All You Need to Know About Adhesives. Richard C. Snogrem. New York, New York: Popular Science, 355 Lexington Avenue, December, 1971.

2. Aluminum - Metal of Many Fa[illegible]es. Pittsburgh, Pennsylvania: Bureau of Mines, United States Dep[illegible]ent of Interior Motion Pictures, 4800 Forbes Avenue.

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